

AUSTRALIAN NUCLEAR SCIENCE
AND TECHNOLOGY ORGANISATION
LUCAS HEIGHTS RESEARCH LABORATORIES

**A REPORT TO
QUASAR RESOURCES**

on

**LABORATORY BATCH TESTS
ATTENUATION OF MINING FLUIDS IN THE 4 MILE AQUIFER**

by

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Prepared by ANSTO Minerals
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October 2008

EXECUTIVE SUMMARY

A series of batch contact tests were undertaken to provide data on the capacity of the Four Mile aquifer material to reduce the acidity and oxidation potential of mining fluid as it passes through the aquifer. The data is to be used to calibrate and validate geochemical modeling work and support information obtained from column tests¹ previously undertaken by ANSTO Minerals.

The objective of the work program was:

- To carry out laboratory batch testwork to assess the interaction of aquifer material/mining fluid over time by monitoring changes in pH and ORP.

Material from three core holes (AKC010, AKC024 and AKC103) east of the 4 Mile ore body were supplied for this work. The compositions are shown below.

Composition of Core Samples (wt%)

	AKC010	AKC024	AKC103
Mg	0.007	0.050	0.31
Al	1.86	2.15	6.35
Si	41.3	41.2	35.8
S	1.02	0.69	0.17
K	0.14	0.34	1.71
Ca	0.045	0.033	0.11
Fe	2.19	2.67	1.75
U (ppm)	30	160	40
Leco			
C	0.602	0.453	0.177
S	1.48	0.914	0.148

Synthetic mining fluid was made-up by doping ground water with uranium and then adding acid to produce solutions at pHs 1.7, 3.0, 4.0 and 5.0. Each core material was contacted with each mining fluid in an agitated tank for 24 h. All tests were done in duplicate, giving a total of 24 tests. pH and ORP were measured as a function of time over a period of 4 days. The final liquor samples were analysed by ICP/OES.

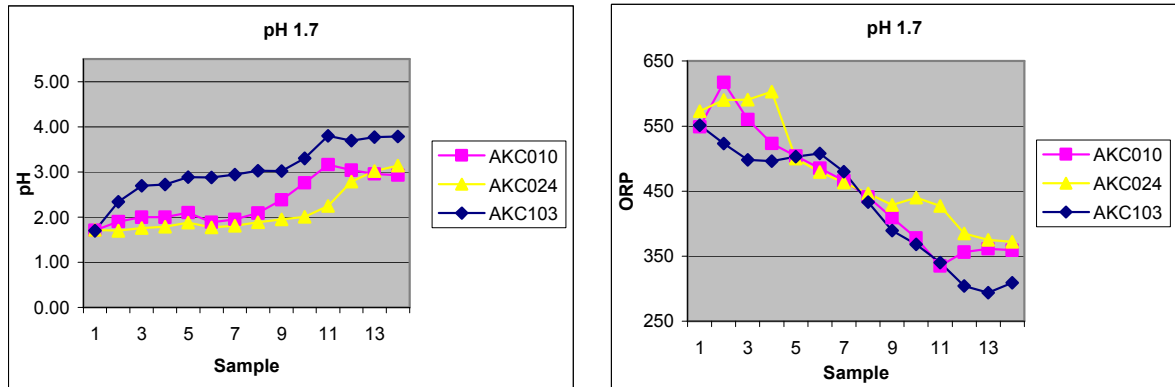
The pH and ORP profiles, for the duplicate tests, and the final solution assays were generally in good agreement. The figures below compare the attenuation curves for all samples for starting pHs of 1.7 and 4.0.

The pH attenuation curves show that the acid consumed by AKC103 was greater than the other two samples at both pH 1.7 and 4.0. The acid consuming capacities of the other two samples were similar at both pHs. The pH trends at pH 4 suggest that AKC010 may have in fact produced acid from the dissolution of an iron sulphide, which is confirmed by the greater iron concentration in the final solution for this sample.

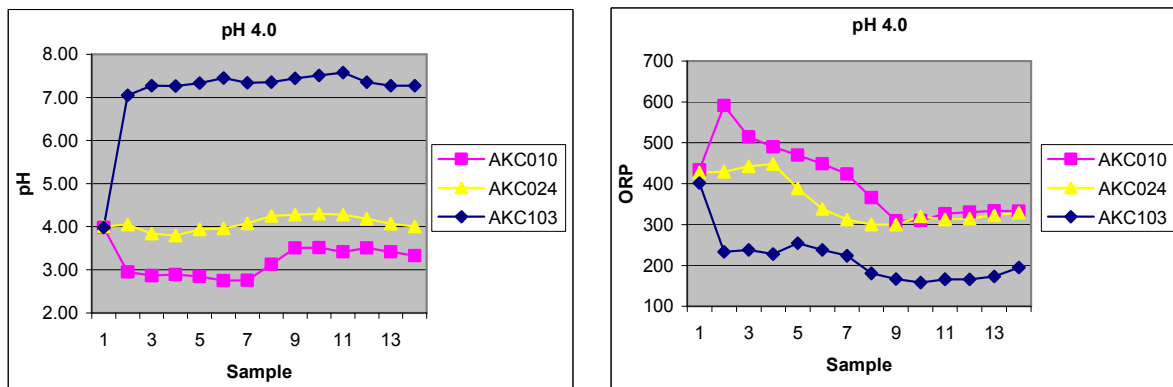
¹ ANSTO Minerals Report C/1019.

The ORP curves for all samples were similar at both conditions, except for AKC103 at pH 4. The low ORP for this test is a result of the high residual pH and the precipitation of all Fe.

The final liquor compositions for the tests showed that the major elements dissolved were Ca, Al, Fe, Mg and Si. Uranium was also dissolved from AKC024 at pH 1.7. Iron dissolution was greatest, at all pHs, from AKC010, which had the greatest S content. This result also confirms the dissolution of an iron sulphide, as discussed above.



Attenuation Curves pH 1.7



Attenuation Curves pH 4.0

Conclusions

The pH and ORP achieved after 4 days contact of the core samples and simulated mining fluid were as follows:

	pH	ORP (mV)
AKC010	3.5	~350
AKC024	3.25-4	330
AKC103	7.5	180

Final solution conditions for all samples were independent of the initial pH of the contact solution, except for AKC024, where the final pH depended on the initial pH.

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1. INTRODUCTION

The purpose of this work was to provide data examining the capacity of the aquifer material to reduce the acidity and oxidation potential of mining fluid as it passes through the aquifer. The data is to be used to calibrate and validate geochemical modeling work and support information obtained from column tests² previously undertaken by ANSTO Minerals.

2. OBJECTIVES

The objective of the work program was:

- To carry out laboratory batch testwork to assess the interaction of aquifer material/mining fluid over time by monitoring changes in pH and ORP.

3. SAMPLES

3.1 Core Samples

Representative material containing no uranium mineralization was supplied by Heathgate Resources. The material was taken from three core holes (AKC010, AKC024 and AKC103) east of the 4 Mile ore body.

Table 1 summarises the material received.

TABLE 1
Core Material Received at ANSTO

Core AKC010	Core AKC024	Core AKC103
195-209 m	185-192 m	161-170 m
209-229 m	198-201 m	170-181 m
229-241 m	201-207 m	181-222 m
~20 kg (total weight)	~60 kg (total weight)	~60 kg (total weight)

3.2 Sample Preparation

The three sections from each core were combined, dried at 60°C for 24 hours, crushed (< 1.7 mm) and mixed, before being split into representative sample lots weighing ~1 kg each.

For each core, one of the 1 kg sample lots was pulverized for head assay.

The solid head samples were analysed at ANSTO using XRF for the following suite of elements: Mg, Al, Si, P, S, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Sr, Y, Zr, Nb, Ba, Ce, Pb, Th, U. Leco analysis for C, N and S was performed by an external laboratory. Head assays are summarised in **Table 2**, with detailed XRF results presented in **Appendix A**. The data in **Table 2** show that AKC103 contained significantly greater concentrations of Mg, Al and K, suggesting a higher silicate/clay content. AKC103 was also noticeably lower in S.

² ANSTO Minerals Report C/1019.

TABLE 2
Composition of Core Samples (wt%)

	AKC010	AKC024	AKC103
Mg	0.007	0.050	0.31
Al	1.86	2.15	6.35
Si	41.3	41.2	35.8
S	1.02	0.69	0.17
K	0.14	0.34	1.71
Ca	0.045	0.033	0.11
Fe	2.19	2.67	1.75
U (ppm)	30	160	40
Leco			
C	0.602	0.453	0.177
S	1.48	0.914	0.148

3.3 Synthetic Mining Fluid

A batch of liquor was made up using 50 L of stored groundwater from the previous 4 Mile Creek testwork program carried out by ANSTO. The testing fluid was made up as follows:

- Concentrated uranium solution was added to achieve a uranium concentration of 50 mg/L.

Using this bulk solution,

- Hydrogen peroxide was added to achieve an ORP of 560 mV; and
- Concentrated sulphuric acid was added to achieve the test pHs of 1.7, 3.0, 4.0 and 5.0.

The amounts of reagents used to make up each of the liquors, together with the compositions are summarised in **Table 3**.

TABLE 3
Compositions of Initial Liquors (mg/L)

	pH 1.7	pH 3.0	pH 4.0	pH 5.0
Al	1.4	1.8	<1	<1
Ca	21	21	21	21
Fe	<1	<1	<1	<1
K	14	13	13	13
Mg	31	30	31	31
Mn	<1	<1	<1	<1
Na	280	280	290	310
P	<1	<1	1.6	1.4
S	620	150	140	150
Si	8.5	7.6	7.6	7.6
U	48	46	42	32
Acid added (mL)	1.35	0.07	0.02	0.0 + 6 drops 1 M NaOH
H ₂ O ₂ added (g of 29.6 wt%)	3.3	3.2	1.75	1.3

4. TESTWORK

4.1 Procedure and Analyses

One kilogram lots of representative, unmineralised core samples were used in the batch testwork. A slurry density of 50 wt% was used so that continuous mechanical stirring could be achieved. Agitation speed was increased for AKC103 after 24 hours due to the thickness of the slurry.

The batch tests, at four different initial pHs, were carried out at 30°C, and pH and ORP measurements recorded at time intervals of 1, 5, 10, 30 minutes, 1, 2, 4, 8, 12, 24 hours, 2 and 4 days. The pH and ORP probes were calibrated prior to taking measurements after the 4 hour readings. Liquor samples were analysed at ANSTO using ICPOES and ICPMS for the following suite of elements:

Al, Ca, Fe, K, Mg, Mn, Na, P, S, Si, U.

Chloride and HCO_3^- were measured using ion selective electrode and titrimetry, respectively.

The batch tests were run in duplicate. The first series was completed for each core and the corresponding data passed on to the client for comment. The client advised ANSTO³ that no modifications to the testing methodology were required for the duplicate runs.

The analytical schedule for the batch testwork is summarised in **Table 4**. Analytical results for all testwork runs are contained in **Appendix C**.

TABLE 4
Sample Analysis Schedule

Sample	Solids	Liquor
<i>ANSTO Testwork</i>		
Core 1	2 (duplicate)	
Core 2	2 (duplicate)	
Core 3	2 (duplicate)	
4 Mile Creek groundwater		2 (duplicate)
Test liquor pH 1.7		input: 1; output: 6 (batch 1 and 2)
Test liquor pH 3.0		input: 1; output: 6 (batch 1 and 2)
Test liquor pH 4.0		input: 1; output: 6 (batch 1 and 2)
Test liquor pH 5.0		input: 1; output: 6 (batch 1 and 2)

4.2 Results

The batch testing run sheets for the 24 tests, summarizing pH and ORP data are contained in **Appendix B**. The reproducibility between runs is summarised graphically in **Appendix C**. **Figure 1a** illustrates the typical reproducibility obtained for testwork on AKC010.

The results for AKC024 were generally good with a few unexplained deviations (**Figure 1b**). The results for AKC103 were also good considering the difficulties with stirring the slurry (**Figure 1c**).

³ Email dated 27 August 2008 from Ben Jeuken.

The analytical results were in very good agreement between each duplicate. The one exception was AKC103 Run 1 pH 3.0, where the sample was clearly contaminated. The measured elemental concentrations indicate that this was not a “minor” contamination. The impeller was changed (along with those at the other pH’s) after 24 hours, however, a “dirty” impeller would not give rise to the levels observed.

ANSTO recommends that the results for AKC103 Run 1 pH 3.0 be disregarded. Given that the reproducibility in analytical results between all other runs in the testwork program was very good, only the data from AKC103 Run 2 pH 3.0 should be used in modeling work.

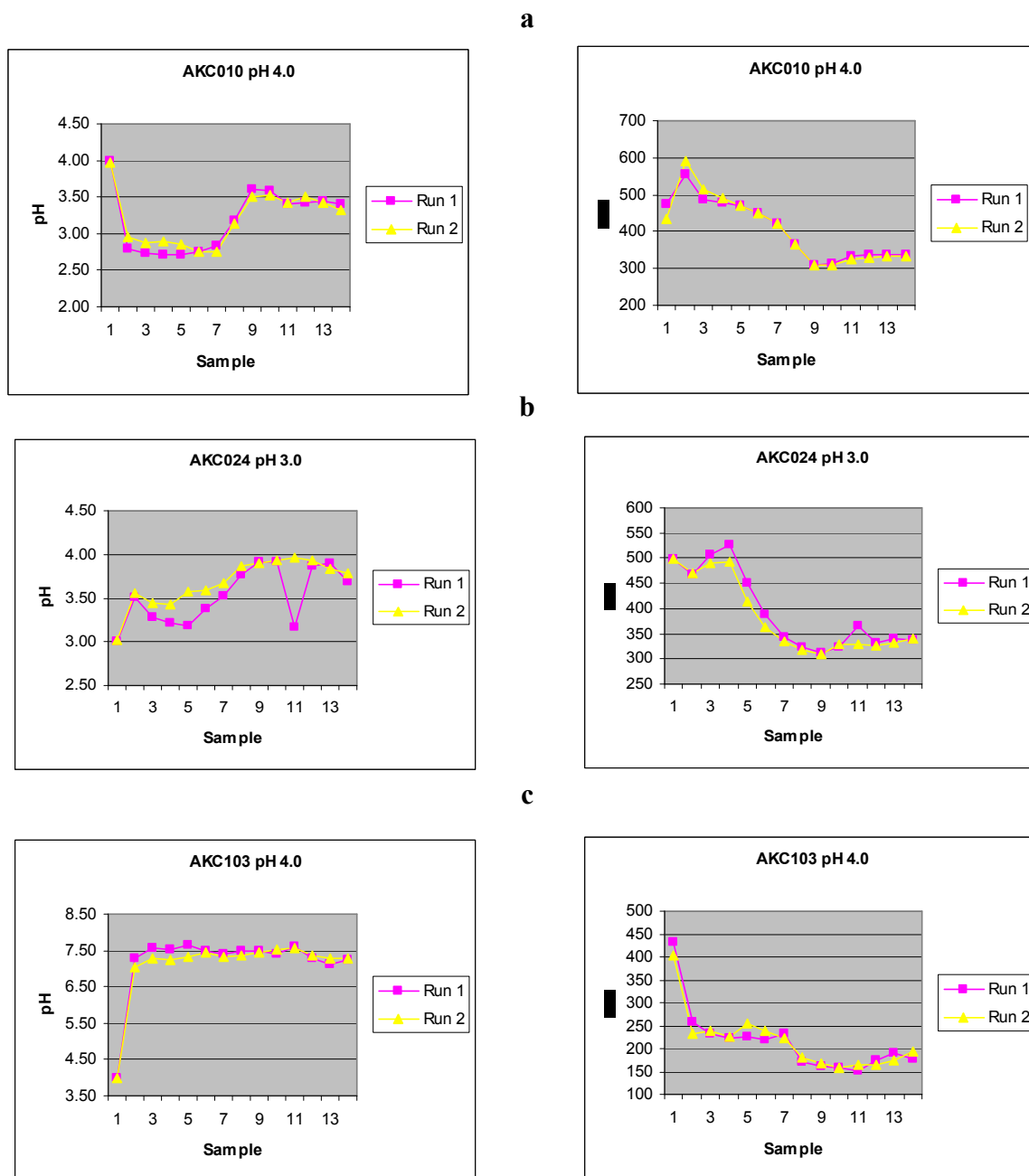


FIGURE 1 Reproducibility of Runs for Batch Contacts

Figures 2 and 3 compare the attenuation curves for all samples for starting pHs of 1.7 and 4.0, respectively (batch 2 runs).

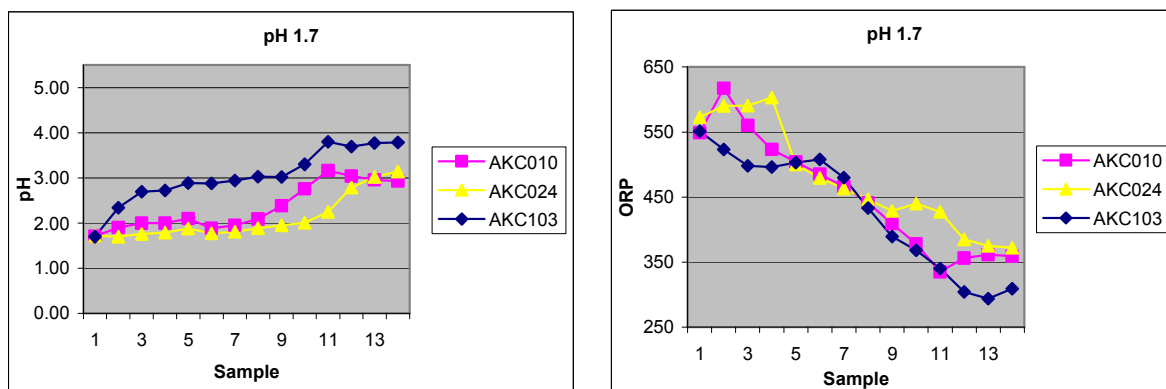


FIGURE 2 Attenuation Curves pH 1.7

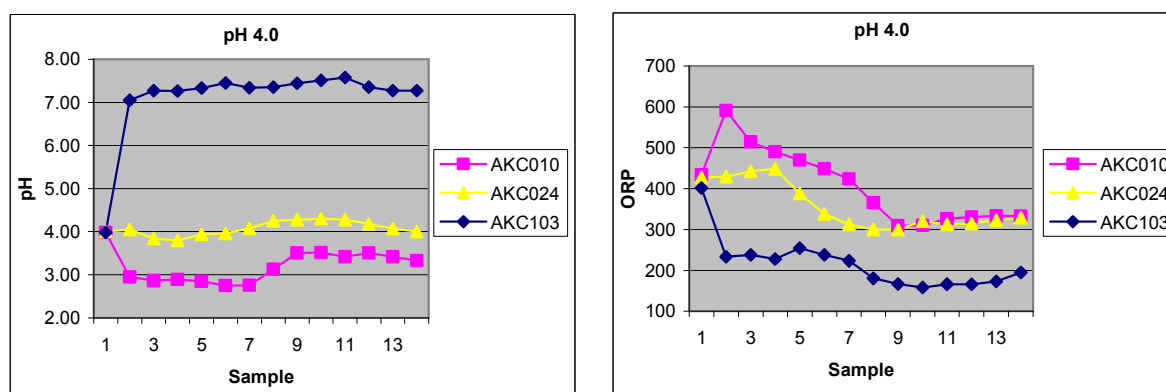


FIGURE 3 Attenuation Curves pH 4.0

The pH attenuation curves show that the acid consumed by AKC103 was greater than the other two samples at both pH 1.7 and 4.0. The acid consuming capacities of the other two samples were similar at both pHs. The pH trends at pH 4 suggest that AKC010 may have in fact produced acid from the dissolution of an iron sulphide, which is confirmed by the greater iron concentration in the final solution for this sample.

The ORP curves for all samples were similar at both conditions, except for AKC103 at pH 4. The low ORP for this test is a result of the high residual pH and the precipitation of all Fe.

Table 4 compares the final liquor compositions for tests in the above figures. The data show that the major elements dissolved were Ca, Al, Fe, Mg and Si. Uranium was also dissolved from AKC024 at pH 1.7. Iron dissolution was greatest, at all pHs, from AKC010, which had the greatest S content. This result also confirms the dissolution of an iron sulphide, as discussed above.

5. CONCLUSIONS

The pH and ORP achieved after 4 days contact of the core samples and simulated mining fluid were as follows:

	pH	ORP (mV)
AKC010	3.5	~350
AKC024	3.25-4	330
AKC103	7.5	180

Final solution conditions for all samples were independent of the initial pH of the contact solution, except for AKC024, where the final pH depended on the initial pH.

TABLE 4
Final Liquor Concentrations for Figures 2 and 3

Analyte	1.7			4.0			Units	
	AKC010	AKC024	AKC103	AKC010	AKC024	AKC103		
Al	200	250	22	74	50	5	mg/L	
Ca	270	210	360	250	170	79		
Fe	560	210	11	160	15	<1		
K	2.2	87	100	13	81	42		
Mg	110	120	210	110	93	46		
Mn	100	8.3	2.0	80	6.5	<1		
Na	420	420	500	470	440	380		
P	<1	2.3	<1	<1	2.1	<1		
S	1280	1390	850	830	590	250		
Si	180	230	110	160	130	9		
U	24	86	9.4	8.5	9.6	<1		
HCO ₃	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		M
Cl	410	480	470	430	480	470		mg/L

6. ACKNOWLEDGMENTS

The author wishes to thank Kelly Hilliard, Brett Robinson and Steven Wolstencroft for assistance with batch tests, and Chris Chipeta and Patricia Gadd for analytical support.

APPENDIX A

CORE SAMPLE ASSAYS BY XRF

Appendix A

Core Sample Assays by XRF (wt%)

REPORT NUMBER: 081969

Job Description: 4 Mile

Report Date: 29th August 2008

Sample name	Na (%)	Mg (%)	Al (%)	Si (%)	P (%)	S (%)	K (%)	Ca (%)	Sc (%)	Ti (%)	V (%)	Cr (%)	Mn (%)	Fe (%)	Co (%)
AKC 010 HEAD A	0.020	0.006	1.9	41.5	0.011	1.0	0.14	0.045	0.004	0.18	0.002	0.044	0.022	2.2	<0.001
AKC 010 HEAD B	0.012	0.008	1.9	41.1	0.006	1.0	0.14	0.045	0.004	0.18	0.001	0.035	0.022	2.2	<0.001
AKC 024 HEAD A	0.018	0.060	2.2	41.1	0.017	0.73	0.33	0.033	0.003	0.22	0.005	0.035	0.005	2.7	<0.001
AKC 024 HEAD B	0.017	0.057	2.1	41.3	0.017	0.65	0.34	0.033	0.004	0.22	0.005	0.052	0.006	2.7	<0.001
AKC 103 HEAD A	0.14	0.31	6.2	35.3	0.018	0.17	1.7	0.11	0.003	0.38	0.002	0.012	0.003	1.8	<0.001
AKC 103 HEAD B	0.14	0.31	6.4	36.4	0.019	0.17	1.7	0.11	0.003	0.38	0.002	0.010	0.003	1.7	<0.001

Sample name	Ni (%)	Cu (%)	Zn (%)	As (%)	Sr (%)	Y (%)	Zr (%)	Nb (%)	Cs (%)	Ba (%)	Ce (%)	Pb (%)	Th (%)	U (%)	LOI (%)
AKC 010 HEAD A	0.008	<0.001	0.006	0.003	0.15	0.008	0.16	0.001	0.010	0.25	0.005	0.002	0.006	0.003	0.5
AKC 010 HEAD B	0.011	<0.001	0.005	0.003	0.15	0.007	0.16	0.002	0.007	0.25	<0.001	0.001	0.005	0.003	1.4
AKC 024 HEAD A	0.002	0.008	0.010	0.007	0.15	0.007	0.16	<0.001	0.007	0.021	0.006	<0.001	0.005	0.015	0.8
AKC 024 HEAD B	0.007	0.008	0.010	0.007	0.15	0.008	0.16	<0.001	0.009	0.019	0.005	0.001	0.006	0.016	0.6
AKC 103 HEAD A	0.003	<0.001	0.004	0.002	0.15	0.011	0.20	0.002	0.008	0.050	0.015	<0.001	0.009	0.004	5.6
AKC 103 HEAD B	<0.001	0.006	0.006	0.002	0.16	0.013	0.20	0.002	0.008	0.055	0.021	0.001	0.011	0.004	2.7

APPENDIX B

Laboratory Run Sheets

HEATHGATE RESOURCES

LABORATORY BATCH TESTWORK

Core ID : AKC010

Run No.: 1

Lab No.: HR-1

Start date: 25.8.08

Finish Date: 29.8.08

Weight Solid: 0.995 kg

Vol. Test Soln: 1 L

Start time: 9.47

Finish time: 9.47

Sample Time	pH	ORP	Comments
TARGET	1.7	560	Vol H ₂ O ₂ = 3.3 g @ 29.6 wt% Vol H ₂ SO ₄ = 1.35 mL
0 min	1.72	546	
1 min	1.92	619	
5 min	1.87	525	
10 min	1.86	511	
30 min	1.87	504	
1 h	1.91	487	
2 h	2.00	471	
4 h	2.16	443	
8 h	2.49	417	
12 h	2.86	382	
24 h	3.16	333	
2 days	3.00	352	
3 days	3.00	361	
4 days	3.04	362	

Client Comments:

HEATHGATE RESOURCES**LABORATORY BATCH TESTWORK****Core ID : AKC010****Run No.: 1****Lab No.: HR-2****Start date: 25.8.08****Finish Date: 29.8.08****Weight Solid: 0.995 kg****Vol. Test Soln: 1 L****Start time: 9.49****Finish time: 9.49**

Sample Time	pH	ORP	Comments
TARGET	3.0	560	Vol H ₂ O ₂ = 3.5 g @ 29.6 wt% Vol H ₂ SO ₄ = 0.07 mL
0 min	3.01	498	
1 min	2.75	596	
5 min	2.64	496	
10 min	2.63	485	
30 min	2.63	478	
1 h	2.66	462	
2 h	2.70	442	
4 h	2.78	416	
8 h	3.09	370	
12 h	3.35	340	
24 h	3.27	337	
2 days	3.18	349	
3 days	3.18	354	
4 days	3.22	356	

Client Comments:

HEATHGATE RESOURCES**LABORATORY BATCH TESTWORK****Core ID : AKC010****Run No.: 1****Lab No.: HR-3****Start date: 25.8.08****Finish Date: 29.8.08****Weight Solid: 0.995 kg****Vol. Test Soln: 1 L****Start time: 9.51****Finish time: 9.51**

Sample Time	pH	ORP	Comments
TARGET	4.0	560	Vol H ₂ O ₂ = 1.75 g @ 29.6 wt% Vol H ₂ SO ₄ = 0.02 mL + 2 drops 1 M NaOH
0 min	4.00	475	
1 min	2.79	556	
5 min	2.73	486	
10 min	2.71	477	
30 min	2.72	470	
1 h	2.76	449	
2 h	2.84	423	
4 h	3.18	367	
8 h	3.61	307	
12 h	3.58	313	
24 h	3.40	335	
2 days	3.43	337	
3 days	3.44	337	
4 days	3.40	339	

Client Comments:

HEATHGATE RESOURCES**LABORATORY BATCH TESTWORK****Core ID : AKC010****Run No.: 1****Lab No.: HR-4****Start date: 25.8.08****Finish Date: 29.8.08****Weight Solid: 0.995 kg****Vol. Test Soln: 1 L****Start time: 9.53****Finish time: 9.53**

Sample Time	pH	ORP	Comments
TARGET	5.0	560	Vol H ₂ O ₂ = 1.3 g @ 29.6 wt% Vol H ₂ SO ₄ = 0.00 mL + 6 drops 1 M NaOH
0 min	5.03	456	
1 min	2.82	518	
5 min	2.76	482	
10 min	2.74	474	
30 min	2.75	468	
1 h	2.78	448	
2 h	2.84	425	
4 h	3.10	379	
8 h	3.55	316	
12 h	3.59	308	
24 h	3.40	331	
2 days	3.39	345	
3 days	3.50	350	
4 days	3.46	354	

Client Comments:

HEATHGATE RESOURCES**LABORATORY BATCH TESTWORK****Core ID : AKC010****Run No.: 2****Lab No.: HR-13****Start date: 1.9.08****Finish Date: 5.9.08****Weight Solid: 0.996 kg****Vol. Test Soln: 1 L****Start time: 9.53****Finish time: 9.53**

Sample Time	pH	ORP	Comments
TARGET	1.7	560	Vol H ₂ O ₂ = 3.3 g @ 29.6 wt% Vol H ₂ SO ₄ = 1.35 mL
0 min	1.71	549	
1 min	1.9	617	
5 min	2.00	560	
10 min	2.00	523	
30 min	2.10	504	
1 h	1.89	485	
2 h	1.95	466	
4 h	2.09	441	
8 h	2.38	409	
12 h	2.76	378	
24 h	3.16	335	
2 days	3.04	356	
3 days	2.96	361	
4 days	2.93	359	

Client Comments:

HEATHGATE RESOURCES**LABORATORY BATCH TESTWORK****Core ID : AKC010****Run No.: 2****Lab No.: HR-14****Start date: 1.9.08****Finish Date: 5.9.08****Weight Solid: 0.995 kg****Vol. Test Soln: 1 L****Start time: 9.55****Finish time:**

Sample Time	pH	ORP	Comments
TARGET	3.0	560	Vol H ₂ O ₂ = 3.5 g @ 29.6 wt% Vol H ₂ SO ₄ = 0.07 mL
0 min	3.01	480	
1 min	2.90	597	
5 min	2.79	515	
10 min	2.79	494	
30 min	2.79	475	
1 h	2.65	458	
2 h	2.65	438	
4 h	2.82	404	
8 h	3.13	351	
12 h	3.38	326	
24 h	3.33	330	
2 days	3.26	347	
3 days	3.20	350	
4 days	3.13	355	

Client Comments:

HEATHGATE RESOURCES**LABORATORY BATCH TESTWORK****Core ID : AKC010****Run No.: 2****Lab No.: HR-15****Start date: 1.9.08****Finish Date: 5.9.08****Weight Solid: 0.999 kg****Vol. Test Soln: 1 L****Start time: 9.57****Finish time: 9.57**

Sample Time	pH	ORP	Comments
TARGET	4.0	560	Vol H ₂ O ₂ = 1.75 g @ 29.6 wt% Vol H ₂ SO ₄ = 0.02 mL + 2 drops 1 M NaOH
0 min	3.98	433	
1 min	2.95	591	
5 min	2.87	514	
10 min	2.89	490	
30 min	2.85	470	
1 h	2.75	449	
2 h	2.76	423	
4 h	3.13	365	
8 h	3.51	309	
12 h	3.52	310	
24 h	3.42	326	
2 days	3.51	330	
3 days	3.42	333	
4 days	3.33	332	

Client Comments:

HEATHGATE RESOURCES**LABORATORY BATCH TESTWORK****Core ID : AKC010****Run No.: 2****Lab No.: HR-16****Start date: 1.9.08****Finish Date: 5.9.08****Weight Solid: 1.001 kg****Vol. Test Soln: 1 L****Start time: 9.59****Finish time: 9.59**

Sample Time	pH	ORP	Comments
TARGET	5.0	560	Vol H ₂ O ₂ = 1.3 g @ 29.6 wt% Vol H ₂ SO ₄ = 0.00 mL + 6 drops 1 M NaOH
0 min	4.95	382	
1 min	2.93	504	
5 min	2.90	486	
10 min	2.92	474	
30 min	2.90	457	
1 h	2.77	443	
2 h	2.80	422	
4 h	3.03	378	
8 h	3.4	323	
12 h	3.48	314	
24 h	3.37	331	
2 days	3.38	344	
3 days	3.34	344	
4 days	3.27	342	

Client Comments:

HEATHGATE RESOURCES**LABORATORY BATCH TESTWORK****Core ID : AKC024****Run No.: 1****Lab No.: HR-5****Start date: 25.8.08****Finish Date: 29.8.08****Weight Solid: 1 kg****Vol. Test Soln: 1 L****Start time: 9.55****Finish time: 9.55**

Sample Time	pH	ORP	Comments
TARGET	1.7	560	Vol H ₂ O ₂ = 3.3 g @ 29.6 wt% Vol H ₂ SO ₄ = 1.35 mL
0 min	1.72	546	
1 min	1.84	575	
5 min	1.84	604	
10 min	1.85	565	
30 min	1.85	520	
1 h	1.91	483	
2 h	1.93	463	
4 h	2.00	445	
8 h	2.07	429	
12 h	2.14	421	
24 h	2.30	408	
2 days	2.70	383	
3 days	3.13	371	
4 days	3.12	369	

Client Comments:

HEATHGATE RESOURCES**LABORATORY BATCH TESTWORK****Core ID : AKC024****Run No.: 1****Lab No.: HR-6****Start date: 25.8.08****Finish Date: 29.8.08****Weight Solid: 1 kg****Vol. Test Soln: 1 L****Start time: 9.57****Finish time: 9.57**

Sample Time	pH	ORP	Comments
TARGET	3.0	560	Vol H ₂ O ₂ = 3.5 g @ 29.6 wt% Vol H ₂ SO ₄ = 0.07 mL
0 min	3.01	498	
1 min	3.51	468	
5 min	3.28	506	
10 min	3.21	526	
30 min	3.19	450	
1 h	3.37	388	
2 h	3.53	343	
4 h	3.77	323	
8 h	3.91	313	
12 h	3.92	322	
24 h	3.16	367	
2 days	3.87	331	
3 days	3.90	339	
4 days	3.69	338	

Client Comments:

HEATHGATE RESOURCES**LABORATORY BATCH TESTWORK****Core ID : AKC024****Run No.: 1****Lab No.: HR-7****Start date: 25.8.08****Finish Date: 29.8.08****Weight Solid: 1 kg****Vol. Test Soln: 1 L****Start time: 9.59****Finish time: 9.59**

Sample Time	pH	ORP	Comments
TARGET	4.0	560	Vol H ₂ O ₂ = 1.75 g @ 29.6 wt% Vol H ₂ SO ₄ = 0.02 mL + 2 drops 1 M NaOH
0 min	4.00	475	
1 min	3.98	439	
5 min	3.71	466	
10 min	3.63	487	
30 min	3.62	421	
1 h	3.76	362	
2 h	3.87	323	
4 h	4.04	307	
8 h	4.10	304	
12 h	4.13	310	
24 h	4.14	358	
2 days	3.96	323	
3 days	3.96	332	
4 days	3.78	335	

Client Comments:

HEATHGATE RESOURCES**LABORATORY BATCH TESTWORK****Core ID : AKC024****Run No.: 1****Lab No.: HR-8****Start date: 25.8.08****Finish Date: 29.8.08****Weight Solid: 1 kg****Vol. Test Soln: 1 L****Start time: 10.01****Finish time: 10.01**

Sample Time	pH	ORP	Comments
TARGET	5.0	560	Vol H ₂ O ₂ = 1.3 g @ 29.6 wt% Vol H ₂ SO ₄ = 0.00 mL + 6 drops 1 M NaOH
0 min	5.03	456	
1 min	4.15	436	
5 min	3.94	455	
10 min	3.90	460	
30 min	3.93	380	
1 h	4.08	332	
2 h	4.22	304	
4 h	4.35	291	
8 h	4.41	291	
12 h	4.41	293	
24 h	4.36	325	
2 days	4.11	314	
3 days	4.08	323	
4 days	3.90	327	

Client Comments:

HEATHGATE RESOURCES**LABORATORY BATCH TESTWORK****Core ID : AKC024****Run No.: 2****Lab No.: HR-17****Start date: 8.9.08****Finish Date: 12.9.08****Weight Solid: 1.008 kg****Vol. Test Soln: 1 L****Start time: 9.40****Finish time: 9.40**

Sample Time	pH	ORP	Comments
TARGET	1.7	560	Vol H ₂ O ₂ = 3.3 g @ 29.6 wt% Vol H ₂ SO ₄ = 1.35 mL
0 min	1.72	573	
1 min	1.70	590	
5 min	1.76	591	
10 min	1.79	603	
30 min	1.88	500	
1 h	1.77	479	
2 h	1.81	463	
4 h	1.89	446	
8 h	1.95	429	
12 h	2.01	440	
24 h	2.25	427	
2 days	2.79	385	
3 days	3.02	375	
4 days	3.14	372	

Client Comments:

HEATHGATE RESOURCES**LABORATORY BATCH TESTWORK****Core ID : AKC024****Run No.: 2****Lab No.: HR-18****Start date: 8.9.08****Finish Date:****Weight Solid: 0.9998 kg****Vol. Test Soln: 1 L****Start time: 9.42****Finish time: 9.42**

Sample Time	pH	ORP	Comments
TARGET	3.0	560	Vol H ₂ O ₂ = 3.5 g @ 29.6 wt% Vol H ₂ SO ₄ = 0.07 mL
0 min	3.02	499	
1 min	3.56	470	
5 min	3.45	491	
10 min	3.42	494	
30 min	3.57	413	
1 h	3.59	363	
2 h	3.67	335	
4 h	3.86	317	
8 h	3.90	309	
12 h	3.93	328	
24 h	3.96	329	
2 days	3.93	326	
3 days	3.83	332	
4 days	3.78	339	

Client Comments:

HEATHGATE RESOURCES**LABORATORY BATCH TESTWORK****Core ID : AKC024****Run No.: 2****Lab No.: HR-19****Start date: 8.9.08****Finish Date:****Weight Solid: 0.9983 kg****Vol. Test Soln: 1 L****Start time: 9.44****Finish time: 9.44**

Sample Time	pH	ORP	Comments
TARGET	4.0	560	Vol H ₂ O ₂ = 1.75 g @ 29.6 wt% Vol H ₂ SO ₄ = 0.02 mL + 2 drops 1 M NaOH
0 min	4.01	427	
1 min	4.05	429	
5 min	3.84	442	
10 min	3.80	448	
30 min	3.94	388	
1 h	3.96	338	
2 h	4.08	312	
4 h	4.25	300	
8 h	4.28	299	
12 h	4.30	320	
24 h	4.28	312	
2 days	4.18	315	
3 days	4.07	322	
4 days	4.00	328	

Client Comments:

HEATHGATE RESOURCES**LABORATORY BATCH TESTWORK****Core ID : AKC024****Run No.: 2****Lab No.: HR-20****Start date: 8.9.08****Finish Date:****Weight Solid: 1.009 kg****Vol. Test Soln: 1 L****Start time: 9.46****Finish time: 9.46**

Sample Time	pH	ORP	Comments
TARGET	5.0	560	Vol H ₂ O ₂ = 1.3 g @ 29.6 wt% Vol H ₂ SO ₄ = 0.00 mL + 6 drops 1 M NaOH
0 min	4.97	363	pH reading 4.7 so NaOH added to increase to 4.97
1 min	4.10	422	
5 min	4.04	382	
10 min	4.06	372	
30 min	4.41	334	
1 h	4.39	304	
2 h	4.40	287	
4 h	4.53	285	
8 h	4.50	284	
12 h	4.54	295	
24 h	4.40	305	
2 days	4.22	304	
3 days	4.12	323	
4 days	3.99	329	

Client Comments:

HEATHGATE RESOURCES**LABORATORY BATCH TESTWORK****Core ID : AKC103****Run No.: 1****Lab No.: HR-9****Start date: 1.9.08****Finish Date: 5.9.08****Weight Solid: 1 kg****Vol. Test Soln: 1 L****Start time: 9.45****Finish time: 9.45**

Sample Time	pH	ORP	Comments
TARGET	1.7	560	Vol H ₂ O ₂ = 3.3 g @ 29.6 wt% Vol H ₂ SO ₄ = 1.35 mL
0 min	1.71	549	
1 min	1.95	545	
5 min	2.10	540	
10 min	2.61	526	
30 min	2.72	522	
1 h	2.60	520	
2 h	2.63	529	
4 h	2.67	455	
8 h	2.67	412	
12 h	2.79	388	
24 h	2.99	335	Changed agitators. Slurry very thick.
2 days	3.42	309	
3 days	3.57	310	
4 days	3.67	309	

Client Comments:

HEATHGATE RESOURCES**LABORATORY BATCH TESTWORK****Core ID : AKC103****Run No.: 1****Lab No.: HR-10****Start date: 1.9.08****Finish Date: 5.9.08****Weight Solid: 0.996 kg****Vol. Test Soln: 1 L****Start time: 9.47****Finish time: 9.47**

Sample Time	pH	ORP	Comments
TARGET	3.0	560	Vol H ₂ O ₂ = 3.5 g @ 29.6 wt% Vol H ₂ SO ₄ = 0.07 mL
0 min	3.01	480	
1 min	6.50	295	
5 min	6.90	257	
10 min	6.91	244	
30 min	7.20	238	
1 h	6.98	236	
2 h	7.05	244	
4 h	7.12	224	
8 h	7.27	203	
12 h	7.07	180	Slurry very thick. Increased stirring.
24 h	7.50	159	
2 days	7.12	183	
3 days	6.99	200	
4 days	7.15	218	

Client Comments:

HEATHGATE RESOURCES

LABORATORY BATCH TESTWORK

Core ID : AKC103

Run No.: 1

Lab No.: HR-11

Start date: 1.9.08

Finish Date: 5.9.08

Weight Solid: 1.005 kg

Vol. Test Soln: 1 L

Start time: 9.49

Finish time: 9.49

Sample Time	pH	ORP	Comments
TARGET	4.0	560	Vol H ₂ O ₂ = 1.75 g @ 29.6 wt% Vol H ₂ SO ₄ = 0.02 mL + 2 drops 1 M NaOH
0 min	3.98	433	
1 min	7.30	258	
5 min	7.56	233	
10 min	7.51	224	
30 min	7.65	225	
1 h	7.49	218	
2 h	7.42	231	
4 h	7.49	170	
8 h	7.49	161	
12 h	7.39	158	
24 h	7.59	152	
2 days	7.29	174	
3 days	7.13	190	
4 days	7.23	179	

Client Comments:

HEATHGATE RESOURCES**LABORATORY BATCH TESTWORK****Core ID : AKC103****Run No.: 1****Lab No.: HR-12****Start date: 1.9.08****Finish Date: 5.9.08****Weight Solid: 1 kg****Vol. Test Soln: 1 L****Start time: 9.51****Finish time: 9.51**

Sample Time	pH	ORP	Comments
TARGET	5.0	560	Vol H ₂ O ₂ = 1.3 g @ 29.6 wt% Vol H ₂ SO ₄ = 0.00 mL + 6 drops 1 M NaOH
0 min	4.95	382	
1 min	7.38	251	
5 min	7.61	236	
10 min	7.61	224	
30 min	7.84	230	
1 h	7.65	218	
2 h	7.58	208	
4 h	7.60	169	
8 h	7.58	155	
12 h	7.58	160	
24 h	7.69	152	
2 days	7.52	169	
3 days	7.39	186	
4 days	7.47	200	

Client Comments:

HEATHGATE RESOURCES**LABORATORY BATCH TESTWORK****Core ID : AKC103****Run No.: 2****Lab No.: HR-21****Start date: 8.9.08****Finish Date:****Weight Solid: 0.9985 kg****Vol. Test Soln: 1 L****Start time: 9.58****Finish time: 9.58**

Sample Time	pH	ORP	Comments
TARGET	1.7	560	Vol H ₂ O ₂ = 3.3 g @ 29.6 wt% Vol H ₂ SO ₄ = 1.35 mL
0 min	1.70	551	
1 min	2.34	523	
5 min	2.69	498	
10 min	2.72	496	
30 min	2.89	503	
1 h	2.88	508	
2 h	2.94	480	
4 h	3.03	433	
8 h	3.02	389	
12 h	3.30	368	
24 h	3.80	340	Agitation increased. Slurry very thick.
2 days	3.70	304	
3 days	3.77	294	
4 days	3.79	309	

Client Comments:

HEATHGATE RESOURCES**LABORATORY BATCH TESTWORK****Core ID : AKC103****Run No.: 2****Lab No.: HR-22****Start date: 8.9.08****Finish Date:****Weight Solid: 1.005 kg****Vol. Test Soln: 1 L****Start time: 10.00****Finish time: 10.00**

Sample Time	pH	ORP	Comments
TARGET	3.0	560	Vol H ₂ O ₂ = 3.5 g @ 29.6 wt% Vol H ₂ SO ₄ = 0.07 mL
0 min	2.96	454	
1 min	6.42	258	
5 min	6.75	232	
10 min	6.88	238	
30 min	7.10	266	
1 h	7.18	241	
2 h	7.05	230	
4 h	7.16	208	
8 h	7.24	190	
12 h	7.31	185	
24 h	7.38	181	Agitation increased. Slurry very thick.
2 days	7.05	172	
3 days	6.90	212	
4 days	6.86	218	

Client Comments:

HEATHGATE RESOURCES

LABORATORY BATCH TESTWORK

Core ID : AKC103

Run No.: 2

Lab No.: HR-23

Start date: 8.9.08

Finish Date:

Weight Solid: 1.002 kg

Vol. Test Soln: 1 L

Start time: 10.02

Finish time: 10.02

Sample Time	pH	ORP	Comments
TARGET	4.0	560	Vol H ₂ O ₂ = 1.75 g @ 29.6 wt% Vol H ₂ SO ₄ = 0.02 mL + 2 drops 1 M NaOH
0 min	3.98	402	
1 min	7.05	233	
5 min	7.27	238	
10 min	7.26	227	
30 min	7.33	254	
1 h	7.45	238	
2 h	7.34	223	
4 h	7.35	180	
8 h	7.44	167	
12 h	7.51	158	
24 h	7.57	166	Agitation increased. Slurry very thick.
2 days	7.35	165	
3 days	7.27	173	
4 days	7.27	194	

Client Comments:

HEATHGATE RESOURCES

LABORATORY BATCH TESTWORK

Core ID : AKC103

Run No.: 2

Lab No.: HR-24

Start date: 8.9.08

Finish Date:

Weight Solid: 1.001 kg

Vol. Test Soln: 1 L

Start time: 10.04

Finish time: 10.04

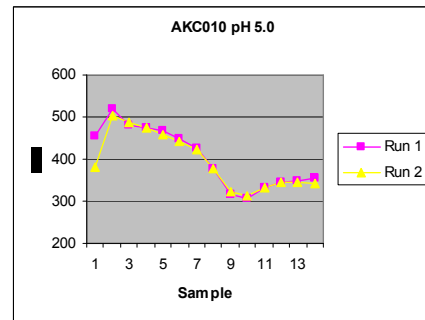
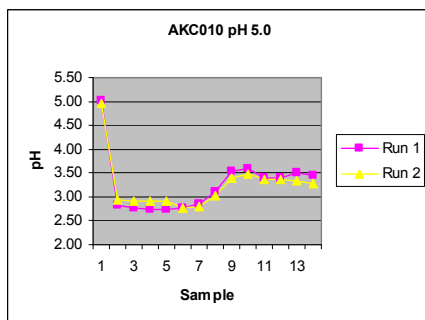
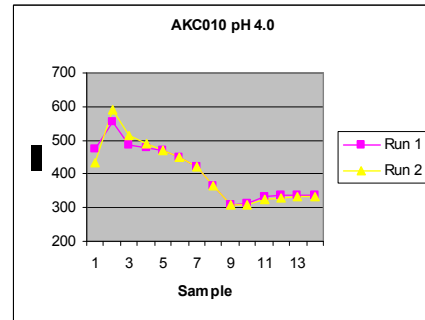
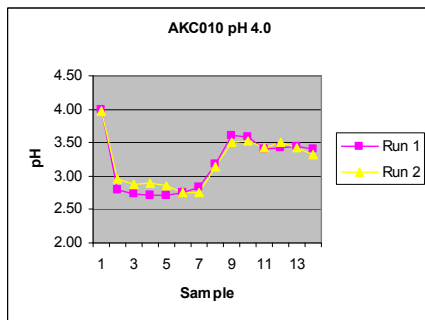
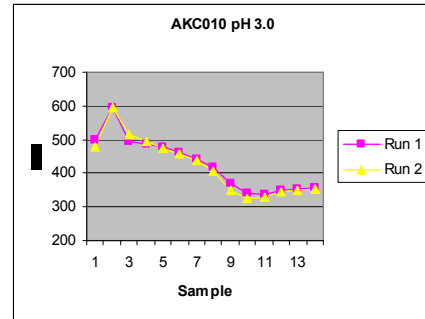
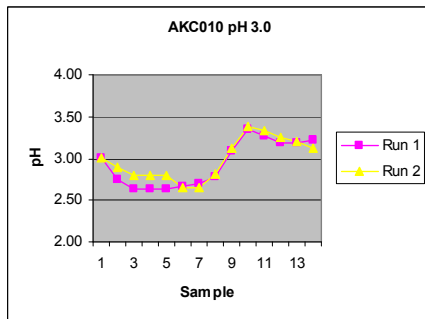
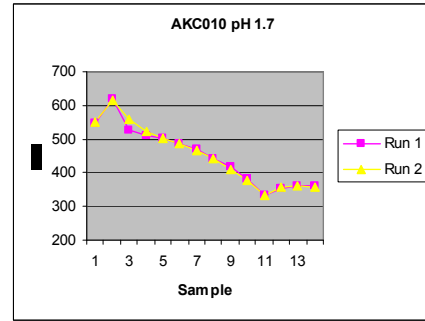
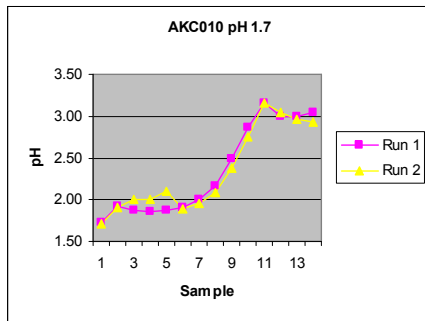
Sample Time	pH	ORP	Comments
TARGET	5.0	560	Vol H ₂ O ₂ = 1.3 g @ 29.6 wt% Vol H ₂ SO ₄ = 0.00 mL + 6 drops 1 M NaOH
0 min	4.98	346	
1 min	7.20	249	
5 min	7.35	247	
10 min	7.37	238	
30 min	7.48	250	
1 h	7.52	189	
2 h	7.45	175	
4 h	7.46	160	
8 h	7.50	154	
12 h	7.54	160	
24 h	7.50	159	Agitation increased. Slurry very thick.
2 days	7.23	172	
3 days	7.14	175	
4 days	7.10	205	

Client Comments:

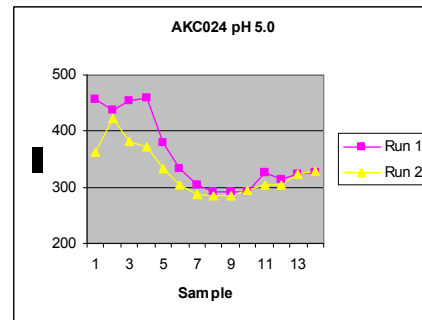
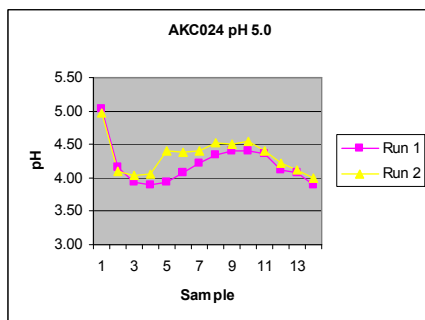
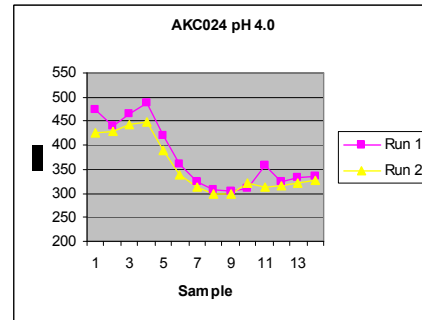
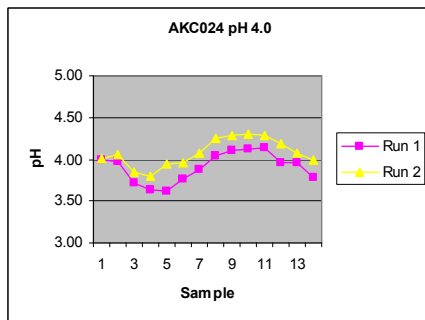
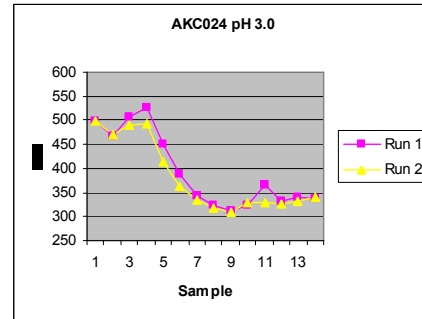
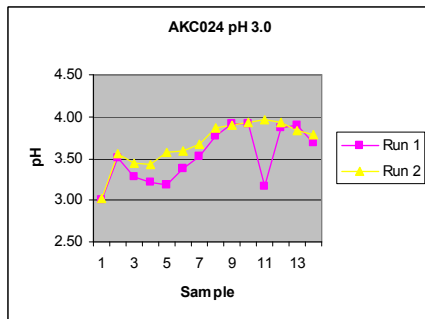
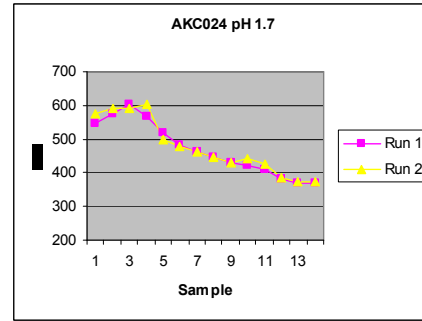
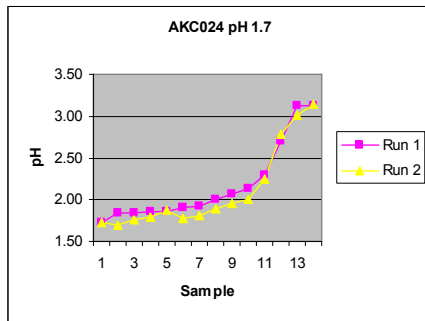
APPENDIX C

Reproducibility of Runs

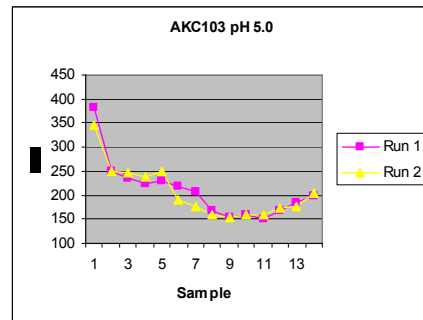
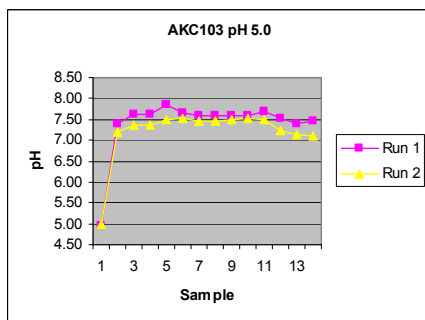
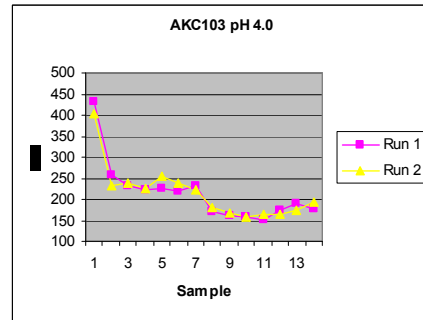
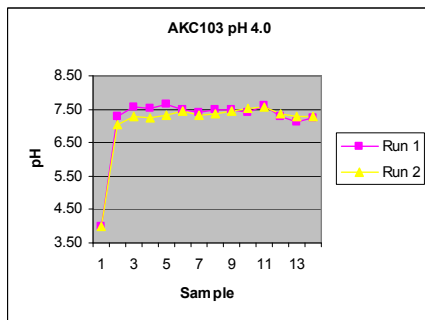
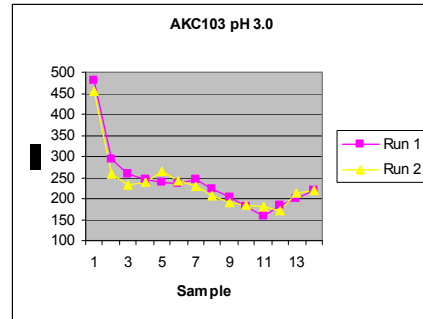
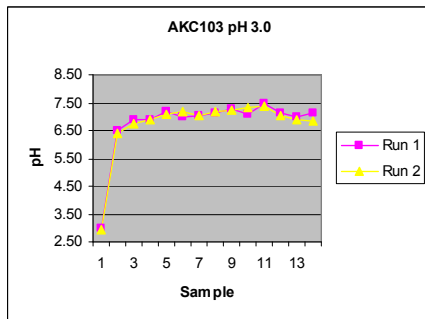
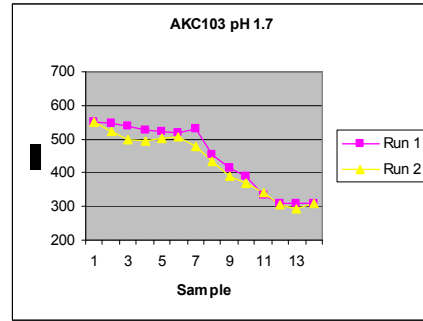
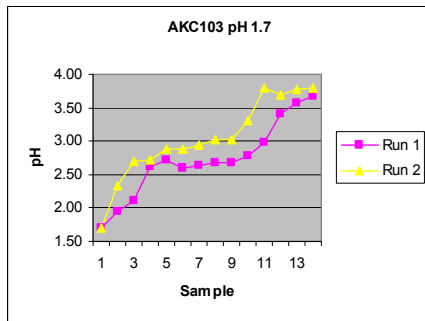
AKC010



AKC024



AKC103



APPENDIX D

Liquor Analyses for Batch Testwork

ICP Analysis of 4 Mile Groundwater

REPORT NUMBER 081968

Job Description: 4 MILE

Report Date: 28 August 2008

SAMPLE ID	4Mile Head N1	4Mile Head N2	Units
Al 396.153	1.20	<1	mg/L
Ca 317.933	19.5	20.1	mg/L
Fe 259.939	<1	<1	mg/L
K 766.490	12.7	13.5	mg/L
Mg 285.213	30.1	31.0	mg/L
Mn 257.610	<1	<1	mg/L
Na 589.592	292	299	mg/L
P 178.221	<1	<1	mg/L
S 180.669	90.9	93.9	mg/L
Si 251.611	12.9	12.3	mg/L
U 409.014	<1	<1	mg/L

AKC010 Runs 1 and 2

pH 1.7 and pH 3.0

pH = 1.7 HR-1			
Al	210	mg/L	
Ca	300		
Fe	550		
K	1.5		
Mg	120		
Mn	110		
Na	470		
P	1.8		
S	1420		
Si	220		
U	27		
HCO ₃	<0.01		M
Cl	430		mg/L

pH = 1.7 HR-13			
Al	200	mg/L	
Ca	270		
Fe	560		
K	2.2		
Mg	110		
Mn	100		
Na	420		
P	<1		
S	1280		
Si	180		
U	24		
HCO ₃	<0.01		M
Cl	410		mg/L

pH = 3.0 HR-2			
Al	81	mg/L	
Ca	270		
Fe	230		
K	3.2		
Mg	100		
Mn	49		
Na	490		
P	<1		
S	860		
Si	100		
U	17		
HCO ₃	<0.01		M
Cl	420		mg/L

pH = 3.0 HR-14			
Al	83	mg/L	
Ca	240		
Fe	160		
K	5.7		
Mg	100		
Mn	59		
Na	440		
P	<1		
S	810		
Si	120		
U	13		
HCO ₃	<0.01		M
Cl	400		mg/L

AKC010 Runs 1 and 2

pH 4.0 and pH 5.0

pH = 4.0		HR-3	
Al	80		mg/L
Ca	280		
Fe	170		
K	14		
Mg	110		
Mn	90		
Na	480		
P	1.2		
S	890		
Si	180		
U	9.6		
HCO ₃	<0.01		M
Cl	420		mg/L

pH = 4.0		HR-15	
Al	74		mg/L
Ca	250		
Fe	160		
K	13		
Mg	110		
Mn	80		
Na	470		
P	<1		
S	830		
Si	160		
U	8.5		
HCO ₃	<0.01		M
Cl	430		mg/L

pH = 5.0		HR-4	
Al	68		mg/L
Ca	260		
Fe	92		
K	12		
Mg	100		
Mn	78		
Na	470		
P	<1		
S	770		
Si	160		
U	9.1		
HCO ₃	<0.01		M
Cl	410		mg/L

pH = 5.0		HR-16	
Al	71		mg/L
Ca	240		
Fe	130		
K	10		
Mg	100		
Mn	71		
Na	480		
P	<1		
S	810		
Si	140		
U	10		
HCO ₃	<0.01		M
Cl	410		mg/L

AKC024 Runs 1 and 2

pH 1.7 and pH 3.0

pH = 1.7		HR-5		
Al	240			mg/L
Ca	220			
Fe	230			
K	74			
Mg	120			
Mn	9.5			
Na	460			
P	<1			
S	1150			
Si	230			
U	88			
HCO ₃	<0.01		M	
Cl	480		mg/L	

pH = 1.7		HR-17		
Al	250			mg/L
Ca	210			
Fe	210			
K	87			
Mg	120			
Mn	8.3			
Na	420			
P	2.3			
S	1390			
Si	230			
U	86			
HCO ₃	<0.01		M	
Cl	480		mg/L	

pH = 3.0		HR-6		
Al	56			mg/L
Ca	210			
Fe	21			
K	62			
Mg	100			
Mn	6.5			
Na	480			
P	<1			
S	600			
Si	120			
U	21			
HCO ₃	<0.01		M	
Cl	490		mg/L	

pH = 3.0		HR-18		
Al	48			mg/L
Ca	180			
Fe	18			
K	60			
Mg	91			
Mn	6			
Na	430			
P	<1			
S	560			
Si	100			
U	16			
HCO ₃	<0.01		M	
Cl	480		mg/L	

AKC024 Runs 1 and 2

pH 4.0 and pH 5.0

pH = 4.0		HR-7	
Al	60		mg/L
Ca	220		
Fe	20		
K	72		
Mg	110		
Mn	5.7		
Na	480		
P	<1		
S	640		
Si	120		
U	16		
HCO ₃	<0.01		M
Cl	500		mg/L

pH = 4.0		HR-19	
Al	50		mg/L
Ca	170		
Fe	15		
K	81		
Mg	93		
Mn	6.5		
Na	440		
P	2.1		
S	590		
Si	130		
U	9.6		
HCO ₃	<0.01		M
Cl	480		mg/L

pH = 5.0		HR-8	
Al	59		mg/L
Ca	210		
Fe	19		
K	86		
Mg	110		
Mn	5.9		
Na	490		
P	1.1		
S	640		
Si	130		
U	12		
HCO ₃	<0.01		M
Cl	490		mg/L

pH = 5.0		HR-20	
Al	57		mg/L
Ca	180		
Fe	19		
K	100		
Mg	99		
Mn	7.9		
Na	460		
P	1.4		
S	670		
Si	130		
U	11		
HCO ₃	<0.01		M
Cl	500		mg/L

AKC103 Runs 1 and 2

pH 1.7 and pH 3.0

pH = 1.7 HR-9		
Al	25	mg/L
Ca	370	
Fe	14	
K	110	
Mg	220	
Mn	2.2	
Na	520	
P	<1	
S	910	
Si	120	
U	10	
HCO ₃	<0.01	M
Cl	440	mg/L

pH = 1.7 HR-21		
Al	22	mg/L
Ca	360	
Fe	11	
K	100	
Mg	210	
Mn	2.0	
Na	500	
P	<1	
S	850	
Si	110	
U	9.4	
HCO ₃	<0.01	M
Cl	470	mg/L

pH = 3.0 HR-10		
Al	420	mg/L
Ca	270	
Fe	2020	
K	92	
Mg	1010	
Mn	340	
Na	770	
P	400	
S	5850	
Si	15	
U	90	
HCO ₃	<0.01	M
Cl	1050	mg/L

pH = 3.0 HR-22		
Al	3	mg/L
Ca	97	
Fe	<1	
K	52	
Mg	56	
Mn	<1	
Na	410	
P	<1	
S	280	
Si	13	
U	<1	
HCO ₃	<0.01	M
Cl	470	mg/L

Repeat ICP analysis pH = 3.0 HR-10		
Al	390	mg/L
Ca	270	
Fe	2070	
K	88	
Mg	1010	
Mn	350	
Na	760	
P	400	
S	5850	
Si	15	
U	120	

AKC103 Runs 1 and 2

pH 4.0 and pH 5.0

pH = 4.0		HR-11	
Al	<1		mg/L
Ca	91		
Fe	1.8		
K	57		
Mg	51		
Mn	<1		
Na	440		
P	<1		
S	320		
Si	12		
U	<1		
HCO ₃	<0.01		M
Cl	500		mg/L

pH = 4.0		HR-23	
Al	5		mg/L
Ca	79		
Fe	<1		
K	42		
Mg	46		
Mn	<1		
Na	380		
P	<1		
S	250		
Si	9		
U	<1		
HCO ₃	<0.01		M
Cl	470		mg/L

pH = 5.0		HR-12	
Al	<1		mg/L
Ca	86		
Fe	<1		
K	47		
Mg	47		
Mn	<1		
Na	430		
P	<1		
S	300		
Si	10		
U	<1		
HCO ₃	<0.01		M
Cl	460		mg/L

pH = 5.0		HR-24	
Al	<1		mg/L
Ca	86		
Fe	<1		
K	47		
Mg	49		
Mn	<1		
Na	400		
P	<1		
S	270		
Si	12		
U	<1		
HCO ₃	<0.01		M
Cl	460		mg/L