This document was prepared in conjunction with work accomplished under Contract No. DE-AC09-96SR18500 with the U. S. Department of Energy.

WSRC-TR-2003-00064, REVISION 0
SRT-RPP-2003-00019, REVISION 0

Key Words:
River Protection Project, Crossflow Filter,
Envelope C Waste,
Hanford Tank 241-AN-107

Retention:
Permanent

Key WTP R&T References:
Test Plan SRT-RPP-2000-00050, Rev. 0
Test Scoping Statement S-51

PILOT-SCALE PRECIPITATION TESTS OF ENVELOPE C SIMULANTS (U)

Michael R. Williams, 786-5A
Timothy J. Steeper, 786-5A

APRIL 2004

Westinghouse Savannah River Company
Savannah River Site
Aiken, SC 29808

Prepared for the U.S. Department of Energy Under Contract Number DE-AC09-96SR18500

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS AND INITIALS

ADS	Analytical Development Section
AN-102	Refers to waste in Hanford tank 241-AN-102. This waste is one of the Envelope C type wastes.
AN-107	Refers to waste in Hanford tank 241-AN-102. This waste is another of the Envelope C type wastes.
ARA	After Reagent Addition. This is a shorthand way to say "after the last reagent was added to the simulant batch."
DIF	Deionized and Filtered (0.2 micron)
EDL	Engineering Development Laboratory, SRTC, WSRC
FBRM	Focused Beam Reflectance Measurement
HLW	High Level Waste
LAW	Low Activity Waste
PJM	Pulse Jet Mixer
RCRA	Resource Conservation and Recovery Act of 1976
RPP	River Protection Project
SRTC	Savannah River Technology Center
Sr/TRU	Strontium and Transuranic elements
TMP	Transmembrane Pressure (the average pressure drop across the thickness of the filter medium – perpendicular to the slurry flow.)
TRU	Transuranic
WGI	Washington Group International
WSRC	Westinghouse Savannah River Company
WTP	Waste Treatment and Immobilization Plant

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1.0 TESTING SUMMARY

1.1 OBJECTIVES

The objectives of this test program were specified in the original task plan (1). During the course of the task, new information resulting from other test programs and maturing plant design led to changes in the specific conditions tested. These changes are documented in two task plan revisions and test exceptions. The net result of these changes is discussed below.

1.1.1 Design, Fabricate, and Install Pilot Precipitation Facilities Coupled to Crossflow Filtration

This objective was met by designing and installing a precipitation facility in the EDL next to and connected to an existing crossflow filter facility. The crossflow filter facility was modified to meet the requirements of this task.

Originally, testing was to use batches of about 650 liters, approximately 1/300 scale of the batch to be treated by the WTP Pretreatment Ultrafiltration System. Actual batch sizes ranged from 570 liters to 880 liters, the varying sizes being determined by factors such as quantity needed to obtain sufficient solid content after filtration or dimensional constraints associated with pulse jet sizing.

The pilot-scale work was intended to provide data that could be compared to the very small, well-mixed actual waste precipitation experiments, and to the slightly larger actual waste and simulant filtration studies conducted in separate tasks. The WTP plans to use pulse jet mixers that will not require maintenance for the life of the plant, but also may not provide the vigorous mixing provided by a mechanical agitator. Since it is not possible to conduct the small real waste experiments with pulse jet mixing, they were done under well-mixed conditions. For comparison, most of the pilot-scale testing was done using a mechanical agitator mounted vertically inside a baffled tank to provide uniform and vigorous mixing. The last batch was run with a pulse jet mixer to help evaluate the effect of mixing on the precipitation.

1.1.2 Precipitate and Filter a Series of Batches at Varying Conditions to Examine the Effect of Feed Material, Reaction Temperature, Degree of Mixing, and Amount of Reagent Used.

This objective was met by precipitating a series of batches of simulant to specified conditions, then filtering the resultant slurry. The test matrix was revised several times as the work progressed. Table 1-1 shows the test matrix evolution.

Table 1-1. Test Matrix Evolution

Reference	Batch #	(1) Simulant	Batch size (liters)	T (^oC)	(2) Agitation	19M NaOH or Solid NaOH		1 M $SrNO_3$			1M $NaMnO_4$		
						OH^- Addition (M)	Free OH	Wait time (min)	Final Conc. (M)	Add rate (l/min)	Wait time (min)	Final Conc. (M)	Add rate (l/min)
Original Task Plan	1	AN-107	600	50	High	None		N/A	0.075	8	10	0.050	8
	2	AN-107	600	20	High	None		N/A	0.075	8	10	0.050	8
	3	AN-102	600	50	High	None		N/A	0.075	8	10	0.050	8
	4	AN-102	600	20	High	None		N/A	0.075	8	10	0.050	8
	5	AN-102	600	50	Low	None		N/A	0.075	8	10	0.050	8
	6	AN-102	600	50	High	None		N/A	0.038	8	10	0.025	8
	7	AN-102	600	50	High	None		N/A	0.075	8	60	0.050	8
	8	AN-102	600	50	High	None		N/A	0.075	23	10	0.050	23
Rev 1 Task Plan	1	AN-107	650	50	High	None	0.04	N/A	0.075	8	10	0.050	8
	2	AN-107	650	20	High	1	0.8	60	0.075	8	10	0.050	8
	3	AN-102	650	50	High	0.7	1	60	0.075	8	30	0.050	8
	4	AN-102	650	25	High	0.7	1	60	0.075	8	30	0.050	8
	5	AN-102	650	25	Low	0.7	1	60	0.075	8	30	0.050	8
	6	AN-102	650	25	High	0.7	1	60	0.020	8	30	0.025	8
	7	AN-102	650	25	High	None	0.3	N/A	0.075	8	60	0.050	8
	8	AN-102	650	35	High	0.7	1	60	0.075	23	30	0.050	23
Test Ex 02-060	1	AN-107	650	50	High	None	0.04	N/A	0.075	8	10	0.050	8
	2	AN-107	650	20	High	1	0.8	60	0.075	8	10	0.050	8
	3	AN-102	880	25	High	None	0.3	N/A	0.030	2	30	0.030	2
	4	AN-102	880	25	PJM	None	0.3	N/A	0.030	2	30	0.030	2
Test Ex 02-076	1	AN-107	650	50	High	None	0.04	N/A	0.075	8	10	0.050	8
	2	AN-107	650	20	High	1	0.8	60	0.075	8	10	0.050	8
	3	AN-102	As rq'd	25	High	None	0.3	N/A	0.030	2	30	0.030	2
	4	AN-102	As rq'd	25	PJM	None	0.3	N/A	0.030	2	30	0.030	2
Rev 2 Task Plan	1	AN-107	650	50	High	None	0.04	N/A	0.075	8	10	0.050	8
	2	AN-107	650	20	High	1	0.8	60	0.075	8	10	0.050	8
	3C	AN-102	880	20	High	None	0.3	N/A	0.030	2	30	0.030	2
	3B	AN-102	880	50	High	0.7	1	60	0.075	2	30	0.050	2
	3A	AN-102	815	25	High	0.7	1	60	0.075	2	30	0.050	2
	4A	AN-102	590	50	PJM	0.8	1	60	0.075	2	30	0.050	2
	4B	AN-102	590	50	PJM	0.8	1	60	0.075	2	30	0.050	2

Batch 4B was not run since sufficient solids were produced in 4A to complete filtration tests.

The conduct of the experiment was essentially the same for all batches, with the detailed variations as shown in the test matrix. The appropriate simulant was mixed and maintained at the desired reaction temperature in a tank with the desired degree of mixing. (Mixing was either the maximum mechanical agitation possible without splashing or vortex formation, or pulse jet mixing at conditions attempting to represent the mixing planned for the plant.) Caustic adjustment of the batch was made when desired by adding either 50 wt % (19M) or solid sodium hydroxide in sufficient quantity to raise the free hydroxide concentration to the level desired in the resultant mixture. The resultant batch was allowed to mix for about an hour as planned for the plant process. One molar strontium nitrate was then added at the volumetrically scaled rate. This was followed a specified time later by the addition of one molar sodium permanganate, again at the volumetrically scaled rate. Sufficient reagents were added to increase the concentration in the precipitation tank to the desired levels.

Filterability of the precipitated slurry was determined by measuring the filtrate production rates while operating the crossflow filter under varying conditions of slurry flow and filter transmembrane pressure. The plant operating conditions were not established at the time Batches 1 and 2 were run, and the filtration portion of the study was much more abbreviated than desirable. The filtration work for later batches was done under a separate task plan and was more complete.

1.1.3 Determine the Amount of Strontium and Lanthanide Surrogates for Radioactive Isotopes that were Removed by Precipitation

This objective was met by taking slurry samples before reagent addition and periodically after reagents addition and analyzing the samples. Some of the samples were filtered quickly to obtain separate liquid and solid analysis.

1.1.4 Determine If Volatile/Flammable Gases are Produced by the Precipitation Reaction

This objective was met by taking vapor samples within six inches of the liquid surface as quickly as possible (within a couple of minutes) after all reagents were added and analyzing the samples. The mechanically agitated tank had a cover to prevent dilution of gaseous products by the room air. The pulse-jet-mixed tank had to be open to the room. During the pulse-jet-mixed run, the vapor sample was collected from inside the pulse jet during the vacuum/vent period. No measurable quantities of volatile/flammable gases were found during the precipitation of any batch.

1.1.5 Determine if Post-Filtration Precipitation Occurs

This objective was met by collecting filtrate samples from the filtrate loop on the crossflow filter test rig and/or from the composite filtrate storage tank. These samples were examined by various means during time periods extending up to several weeks for evidence of post-filtration solids formation. Some post-filtration solids formed in the filtrate from each batch with sufficient time. The filtrate from the pulse-jet-mixed batch had 4 grams of solid per liter of filtrate one week after filtration was completed.

1.2 TEST EXCEPTIONS

Test Exception	Description
24590-WTP-TEF-RT-02-060	Changed the number of experiments from eight to four and specified pulse-jet mixing for the last experiment.
24590-WTP-TEF-RT-02-076	Specified running multiple batches as necessary to obtain sufficient solids for concentration to at least 15 wt%.
24590-WTP-TEF-RT-03-027	Added requirements for a mini-precipitation to confirm acceptability of simulant prior to each pilot-scale run; eliminated running a 13-point filtration test matrix on the dilute-feed slurry.

1.3 RESULTS AND PERFORMANCE AGAINST SUCCESS CRITERIA

The Pilot-Scale Precipitation Test Facility established the test conditions and processed the simulants to produce slurry for subsequent filtration. It provided the samples required to determine the amount of strontium and lanthanide surrogates removed and if volatile gases were produced by the precipitation reaction. Surrogates were used for Strontium-90 and transuranic material present in the AN-102 and AN-107 radioactive waste. Non-radioactive strontium was used as a surrogate for Strontium-90. Cesium, Lanthanum, and Neodymium were used as surrogates for other transuranics such as Curicum-242, Americium-241, and Plutonium-239. These surrogates were the same as used by Nash et al. (10) for bench-scale studies. The Crossflow Filter measured the filterability and provided filtrate samples for evaluation of post-filtration solid formation.

Table 1-2 summarizes the test matrix (as finally evolved) and the results of all batches processed. All batches had a large percentage of strontium and the lanthanide surrogates removed from the liquid. In particular, the pulse-jet-mixed batch at the baseline chemistry and temperature (4A) performed very well in amounts removed. On the other hand, the filterability of the slurry showed significant variability depending on processing conditions. Although the pulse-jet-mixed batch (4A) met the minimum acceptable filtration rate of 0.02 gpm/ft^2 of filter area, the mechanically mixed batch processed at the same baseline chemistry (3B) filtered much better.

Vapor samples were collected and analyzed for volatile gases evolving near the liquid surface. No trace of volatile gas was found during processing of any batch.

The filtrate from all batches produced some solids with time.

1.4 QUALITY REQUIREMENTS

This work was conducted in accordance with the RPP-WTP QA requirements specified for work conducted by SRTC as identified in DOE IWO M0SRLE60. SRTC has provided matrices to WTP demonstrating compliance of the SRTC QA program with the requirements specified by WTP. Specific information regarding the compliance of the SRTC QA program with RW-0333P, Revision 10, NQA-1 1989, Part 1, Basic and Supplementary Requirements and NQA-2a 1990, Subpart 2.7 is contained in these matrices.

A Test Specification was not written specifically for the pilot precipitation work. The approved Task Technical and Quality Assurance Plan (1) specified the WSRC QA requirements that would be applied. These requirements were followed.

Table 1-2. Test Matrix and Results

Batch #	(1) Simulant	Entrained Solids (wt%)	Batch size (liters)	T (^oC)	(2) Agitation	19M NaOH or Solid NaOH: OH^- Addition (M)	19M NaOH or Solid NaOH: Free OH	1 M $SrNO_3$: Wait time (min)	1 M $SrNO_3$: Final Conc. (M)	1 M $SrNO_3$: Time to add (min)	1M $NaMnO_4$: Wait time (min)	1M $NaMnO_4$: Final Conc. (M)	1M $NaMnO_4$: Time to add (min)	(3) Percent Removed/ DF: Ce	(3) Percent Removed/ DF: La	(3) Percent Removed/ DF: Nd	(3) Percent Removed/ DF: (4) Sr	Precipitate wt% (5)	(6) Average Filtrate Flux to Reach wt%: 5 wt%	(6) Average Filtrate Flux to Reach wt%: 15 wt%	Final Conc wt%
1	AN-107	0.5	647	50	High	None	0.04	N/A	0.075	4.8	10.0	0.05	7.0	80.7	88.1	85.9	99.9	3.2	0.03		
														5.2	8.4	7.1	1013				
2	AN-107	0.5	634	20	High	1	0.8	60	0.075	4.8	10.0	0.05	7.0	89.4	91	86.6	97.2	3.5	0.03	0.02	
														9.4	11	7.5	36				
3C	AN-102R2	0.1	880	25	High	None	0.3	N/A	0.03	17.3	30.0	0.03	17.3	80.7	84.7	82.0	99.2	0.8	0.013		8.3
														5.2	6.5	5.6	126				
3B	AN-102R2	0.1	880	50	High	0.74	0.96	60	0.075	43.2	30.0	0.05	28.8	80.8	82.8	74.6	99.4	1.2	0.060	0.049	21.7
														5.2	5.8	3.9	128				
3A	AN-102R2	0.1	815	25	High	0.74	1.0	60	0.075	40.2	30.0	0.05	26.6	83.8	90.4	77.0	97.4	1.6	0.026	0.020	25.3
														6.2	10	4.3	38				
4A	AN-102R2	0.1	572	50	PJM	0.74	1.0	60	0.075	31.2	30.0	0.05	20.6	90.1	95.5	91.7	98.6	1.5	0.021	0.020	18.3
														10	22	12	72				

Notes	
1	AN-107 simulant was mixed and used at 5.5 M Na. AN-102R2 simulant was mixed at 6.5 M Na by combining a partial simulant with additional chemicals, aged at least 1 week, then diluted to 6 M Na just prior to using.
2	High = 12.8" Lightnin A-310 style impeller in a 42" diameter baffled tank turning at 327 rpm for batches 1 & 2, and 508 rpm for batch 3. PJM = pulse jet mixer pulsing 6% of the tank volume with a 1.6 second drive pulse repeated every 77 seconds.
3	The amounts removed were based on analysis of samples obtained during processing of each batch. It became apparent as work progressed that these samples were not stable, and the analysis varied depending on how much time elapsed before the analysis was made. Continuous improvement was made with each batch in sample handling, with the analysis of the last batch run (4A) being the most reliable. Some of the variation in amount removed may be due to sampling handling rather than actual processing conditions. The removal values for Batch #3B had to be based on the 2 hr samples because the ICP-ES instrument broke before the 3 & 4 hr samples could be run.
4	The pilot scale work cannot actually measure the amount of Sr-90 that would be removed as no radioactive isotopes could be used. The percent of Sr removed and DF shown are based on the recipe amount and assume 100% isotopic dilution by the nonradioactive Sr added as part of the process. This represents the theoretical maximum that can be obtained. It is important to note that the results of small scale experiments with radioactive strontium have not reached this theoretical maximum.
5	The solids amount increased from the entrained wt% amount in the stimulant feed to the Precipitate wt% after the Sr/TRU reaction and to the Final Conc wt% after concentration in the crossflow filter. The wt% for batches 1 & 2 must be considered maximum values only. The material collected by simple filtration contained some dissolved salts that were left behind as contaminates to the insoluble solids. The wt% for batches 3 & 4 were obtained with an analytical technique that acounted for the dissolved salts so are the true insoluble solid content.
6	Units are gpm/ft^2 of filter area at an axial velocity of 12 ft/sec and TMP of 40 psi for batches 3 & 4. Batch 1 was only filtered for a few hours; the flux shown was obtained at V=12 & TMP=33 at a solid content <5 wt%. The wt% solids for Batch 2 was not measured during filtration; 0.03 gpm/ft^2 was obtained at V=16 & TMP=45 early during dewatering, 0.02 was obtained at V=15.4 & TMP=49 near the end of dewatering when the slurry had been concentrated by a factor of 10. Batch 3C was only concentrated to 8.3 wt% as the test was stopped due to poor filtration.

1.5 R & T TEST CONDITIONS

A Test Specification was not issued for this task. The Test Specification TSP-W375-01-0001, Revision 0, Sr/TRU Precipitation Reaction Rate, dated January 23, 2001, was used as a reference in the preparation of the Task Technical and QA Plan, WSRC-TR-2000-00496, Revision 0, dated June 12, 2001 (1) and Revision 1 dated November 30, 2001 (25).
Table 1-2 provides a summary of test conditions implemented in the Task technical and QA Plan. The Task plan was written against the RPP WTP Test Scoping Statement S-51.

1.6 SIMULANT USE

This pilot-scale testing was done entirely with simulants. No facilities were available that could test this process at the pilot scale with the highly radioactive real waste. Also, the required quantity of real waste would have been prohibitively expensive to obtain and handle. In a separate task (Eibling, 23), non-radioactive simulants were developed containing metal salts, organic compounds, and entrained solids providing a good elemental match based on analysis of small samples of the real waste. The organic compounds in the real waste are a complicated mix of chemicals used in processes that produced the wastes originally, and their breakdown/recombination products resulting from long-term storage in a highly radioactive environment. Organic compounds included in the simulant were selected to be representative of major species present in the real waste and believed to be significantly involved in the reactions of interest. Some elements such as plutonium and americium have no non-radioactive isotopes, but knowing their behavior during the process is vital. Lanthanide surrogates (15) for these key radioactive isotopes of interest were included in the simulants.

Numerous beaker-scale real waste precipitation studies have been made by others. Several real waste and simulated waste studies have been made in several-liter-sized precipitation tanks connected to Cell Ultra Filtration (CUF) units. The results of the several-hundred-liter-sized pilot-scale tests of this task should be compared to the smaller-scale experiments.

1.7 DISCREPANCIES AND FOLLOW-ON TESTS

None

2.0 CD-ROM ENCLOSURES

The report is contained on a CD-ROM in Acrobat format. Excel files of the raw data collected by the data acquisition systems during precipitation and filtration of these batches, the reported results of sample analysis, and calculations made for the report are also contained on the CD-ROM. The following file formats were used:

Adobe Acrobat, Version 6.0
Microsoft Excel, Version 97

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3.0 DISCUSSION

3.1 BACKGROUND

The River Protection Project (RPP) is an effort by DOE to process approximately 190 million curies in 54 million gallons of highly radioactive and mixed hazardous waste stored in underground storage tanks at the Hanford Site. The tank waste includes solids (sludge), liquids (supernate), and salt cake (dried salts that will dissolve in water forming supernate). The waste tanks will be remediated through treatment and immobilization to protect the environment and meet regulatory requirements. DOE determined that the preferred alternative to remediate the Hanford Tank Site Waste is to:

- Pretreat the waste to separate it into two fractions, Low-Activity Waste (LAW) and High-Level Waste (HLW)
- Immobilize the LAW for onsite disposal
- Immobilize the HLW for ultimate disposal in a national repository

LAW is a mixed, characteristic, and listed waste regulated under the Resource Conservation and Recovery Act of 1976 (RCRA), and must meet certain treatment standards and performance standards for onsite disposal of the waste form. LAW is comprised of the tank waste liquids (and dissolved saltcake) containing the bulk of the tank waste chemicals and certain radionuclides (e.g., cesium, technetium, strontium, and transuranics) that must be at least partially removed prior to immobilizing the waste. The Sr/TRU is precipitated by the addition of strontium nitrate and sodium permanganate. The Sr/TRU precipitate and entrained solids are collected by filtration with the concentrated product routed to HLW for vitrification.

HLW is comprised of the long half-life elements contained in the tank waste solids and high activity radionuclides separated from the LAW fraction. HLW is a mixed, characteristic, and listed waste regulated under RCRA, and must meet specific treatment and performance standards for storage and repository disposal of the final waste form.

The scope of SRTC pilot-scale precipitation testing per Test Scoping Statement S-51 is to demonstrate operability and determine throughput for the Sr/TRU precipitation process by investigating the precipitation process with strontium nitrate and sodium permanganate on a significantly larger scale than has been done previously. Six batches of simulated waste were processed through the Pilot-Scale Precipitation Test Facility and coupled Crossflow Filter Test Rig under various process parameters including those of temperature, amount of reagent addition, and type of mixing. Non-radioactive simulants of tank AN-102 and AN-107 wastes were used. Results from this testing are compared to bench-scale testing previously performed with real and simulated wastes.

3.2 BATCH NOMENCLATURE

Naming the batches is not intended to be confusing, but a little explanation will be helpful in understanding the nomenclature. Batches 1 and 2 are straightforward. Batch 1 was mixed and precipitated, and then Batch 2 was mixed and precipitated.

Originally we intended to run Batch 3 at one set of conditions, but expected to need a large quantity of simulant to obtain the necessary amount of precipitated solids to reach the desired wt% solids after concentration by the crossflow filter. Because of limited tank size, the simulant had to be mixed in sub-batches. Three sub-batches of chemicals were mixed, nominally identically except for quantity, but labeled batches 3A, 3B, and 3C so we could keep the samples straight in case there was some significant variation discovered after analysis. These batches were mixed and numbered sequentially with the first two batches drummed off to empty the tank for the next batch. Batch 3C was the last batch in the tank when it came time to run the precipitation. Therefore, Batch 3C was the first of the three batches to be precipitated. That batch turned out to have considerable more solids than expected, but very poor filtration characteristics. In an attempt to improve the filterability, the conditions were changed before running the next batch, 3B. Batch 3B also had sufficient solids for the filtration portion of the experiment, and it filtered well. The decision was made to again change the conditions before precipitating the next sub-batch in order to learn more about the process.

When Batch 3A was originally mixed, some of it was provided to others to run separate small-scale experiments. That made the quantity of Batch 3A remaining small enough that there was again concern that there would be insufficient solids. Batch 3B was the largest batch mixed, and a drum of it remained unused. A new Batch 3A was made by mixing the original Batch 3A and the remaining Batch 3B simulant. All Batch 3A samples prior to loading the batch into the tank for the precipitation refer to the original batch; all samples afterward refer to the new Batch 3A.

Batch 4 is also straightforward. It was to be precipitated with pulse jet mixing instead of mechanical mixing. The pulse jet mixed tank was smaller than the mechanically agitated tank, so we expected to need two batches of simulant to have sufficient solids. Batch 4A was the first pulse jet mixed precipitation to be run. It had sufficient solids and Batch 4B was not needed and is still stored in drums.

3.3 PRIOR WORK

3.3.1 AN-107 Simulant

Bench-scale work by Nash et al. (10) used AN-107 simulant with additional caustic added and precipitated with 0.075 M strontium nitrate and 0.04 M sodium permanganate to produce decontamination factors of 91 for strontium, 2.8 for cerium, >4.2 for lanthanum, and 3.4 for neodymium.

3.3.2 AN-102 Large C Supernatant Liquid

Sr/TRU precipitation reactions performed on 16.5 liters of Tank 241-AN-102 Large C supernatant liquid containing entrained solids were also reported by Nash et al. (11). Strontium decontamination factors ranging from 40 to 50 were achieved in this study. They concluded that strontium-90 levels are reduced by simple isotopic dilution with non-radioactive strontium nitrate addition through precipitation of strontium carbonate, and that strontium decontamination factors can be predicted *a priori.* Transuranic elements including plutonium, curium, and americium were reported to have decontamination factors between 2.9 and 12.4. They concluded that addition of permanganate destroys organics that form soluble complexes with TRU elements, thus precipitating lanthanides and TRU elements. The concentrations of Tc and Cs in the liquid were unaffected by the Sr/TRU reaction. They reported some discoloration of the high sodium filtrate bottles after several days, which could be attributed to trace amounts of post-filtration solid formation. Free solids were observed in the lower sodium content filtrate from washing operations after the filtrate was allowed to stand for two days.

3.3.3 AN-102 Small C Liquid

A 1.2 liter Small C sample from Tank 241-AN-102 was caustic adjusted and strontium and permanganate precipitated, as reported by Nash et al (13), to produce a filtrate product decontamination factor of 30 for Sr-90, 9.2 for Am-241, and 7.2 for Cm-244.

3.3.4 AN-107 Simulant Pilot-Scale Precipitation

Duignan (17) reported on a pilot scale precipitation of a 6M sodium AN-107 simulant at 50 ^{o}C by the addition of sodium hydroxide, strontium nitrate, and sodium permanganate. Target levels were 0.075M strontium and 0.05M manganese. He reported filtrate production rates of: 0.03 gpm/ft^2 at 9 ft/sec axial velocity and 32 psid transmembrane pressure, 0.04 gpm/ft^2 at 12 ft/sec and 51 psid, and 0.07 gpm/ft^2 at 15 ft/sec and 30 psid. He found the filtrate flux was strongly affected by the slurry velocity, but only weakly by the transmembrane pressure in the 30 to 55 psid range. During dewatering of his slurry, the filtrate rate gradually decreased from about 0.07 gpm/ft^2 at 2 wt% to 0.01 gpm/ft^2 at 22 wt% insoluble solids. Although not the major focus of Duignan's work, decontamination factors were calculated as follows: 69 for Sr, 20 for La, 22 for Fe, 2 for Cu and Ca, and approximately 1 for P, S, Ni, and Al.

3.3.5 AN-107 Diluted Waste

Hallen et al (18) treated a 1.4 liter sample of diluted actual AN-107 tank waste by adding sodium hydroxide, strontium nitrate, and sodium permanganate. Target concentrations for the final treated waste were 6.0 M sodium, 1.0 M hydroxide, 0.075 M strontium, and 0.05 M permanganate. The waste was thoroughly mixed between each reagent addition. After adding the permanganate, the waste was mixed for 30 minutes at ambient conditions, then heated for 4 hours at 50 ^oC. Filtration was carried out in a Cell Unit Filtration (CUF) system equipped with a 0.1-μm filter element. Their filtrate sample number DF-11 had decontamination factors of 82 for Sr-90, 28 for Am-241, and 22 for Cm-242. Their composite filtration sample DF-20 supernate had decontamination factors of 78 for Sr-90, 38 for Am-241, 32 for Cm-242, and 24 for Pu-239. They reported that 74% of the neodymium was removed based on their DF-20 filtrate composite sample. [Although not reported directly by them, the DF for Nd can be calculated based on their results as (1/(1-0.74)) = 3.9.] Filtration was first conducted with the filtrate returned to the slurry feed tank to maintain a constant concentration. The plot of the first CUF run at 12 ft/sec axial velocity and 49 psid transmembrane pressure showed the filtrate flux starting at about 0.07 gpm/ft^2, rapidly dropping to 0.037 gpm/ft^2 within 10 minutes, then gradually falling off to about 0.025 gpm/ft^2 after an hour of filtration. In their Table 3.10, the average flux for Test #1 was reported as 0.030 gpm/ft^2. Further examination of their tabulated data for filtration at constant concentrations shows trends.

Test #1 and Test #1 were run at similar velocities, but TMP = 49 and 30 respectively, a decrease of 19 psid with a corresponding decrease of 0.005 gpm/ft^2 in average flux. Test #3 and Test #4 were run at similar velocities, but TMP = 69 and 50 respectively, a decrease of 19 psid with a corresponding decrease of 0.003 gpm/ft^2. The average flux appears to decrease with a decrease in TMP, but the effects seem to be less at higher TMPs. Test #1 and Test #4 were run at similar TMPs, but V = 12.0 and 9.0 respectively, a decrease of 3 ft/sec with a corresponding decrease of 0.011 gpm/ft^2 in average flux. Test #6 and Test #4 were run at the same TMP, but V = 11.0 and 9.0 respectively, a decrease of 2.9 ft/sec with a corresponding decrease of 0.003 gpm/ft^2 in average flux. The average flux appears to decrease with a decrease in velocity. Test #1 and Test #6 were run at nearly identical TMPs and velocities, but showed a decrease of 0.008 gpm/ft^2 in average flux. This result appears to show a decrease in filter performance from accumulated use, which complicates the interpretation of the data.

3.4 EQUIPMENT DESCRIPTION

3.4.1 Pilot Scale Precipitation Test Rig

The originally planned 650-liter batch size approximates a 1/300 scale of the full-size batch, 48,383 gallons per Bergman (16), precipitated in the Ultrafiltration Preparation Vessel by the WTP Ultrafiltration System. Actual batch sizes varied from 650 to 880 liters in the mechanically agitated tank and 572 liters in the pulse-jet-mixed tank. Batch sizes were raised in the mechanically agitated tank to provide enough slurry for concentration to at least 15 wt% insoluble solids. The batch size in the pulse-jet-mixed tank was limited by dimensional constraints associated with matching the pulse tube to one used in previous studies by others, and meeting related tank dimension ratios.

Figure 3-1 is a schematic of the Mechanically Agitated Pilot Scale Precipitation Test Rig assembled in the rear of the Engineering Development Laboratory, Building 786-A. The rig was fabricated utilizing PVC and CPVC plastic pipe with tubing made of stainless steel and polypropylene. A 938-liter polypropylene tank with baffles was provided for mixing the simulants and performing the precipitation. A vertically mounted Lightnin agitator with 12-inch diameter A-310 style impeller provided vigorous uniform mixing of the simulant in the tank without splashing. (Note: The interim Batch 1 report incorrectly stated an 8.4-inch impeller was used.) A speed controller allowed agitator speed to be adjusted depending on batch size. This tank was used for Batches 1-3 to provide vigorous mixing to match the smaller-scale real waste studies performed by others. WTP is planning to precipitate in an unbaffled tank with pulse jet mixers. Figure 3-2 is a schematic of the Pulse Jet Mixed Pilot Scale Precipitation Test Rig used for Batch 4 to evaluate the mixing issue. The two rigs shared most of the auxiliary equipment.

The temperature of a batch was raised to the desired level by pumping the contents of either tank through a large recirculation loop containing an electric heater and a chilled water heat exchanger. The large recirculation loop pump had a speed controller to vary the flow as necessary. The large loop is also used with the mechanically agitated tank to maintain the temperature during the precipitation and to provide additional mixing as the tank is drained while feeding the Crossflow Filter Rig. A separate smaller recirculation loop with its own heater was provided for the pulse jet mixed tank to maintain the temperature during precipitation. A separate recycle system was needed because the large pump exceeded the scaled down prototypical plant recycle flow at its lowest setting and provided excessive, non-prototypic mixing. A single heater control unit was manually switched between heaters as necessary.

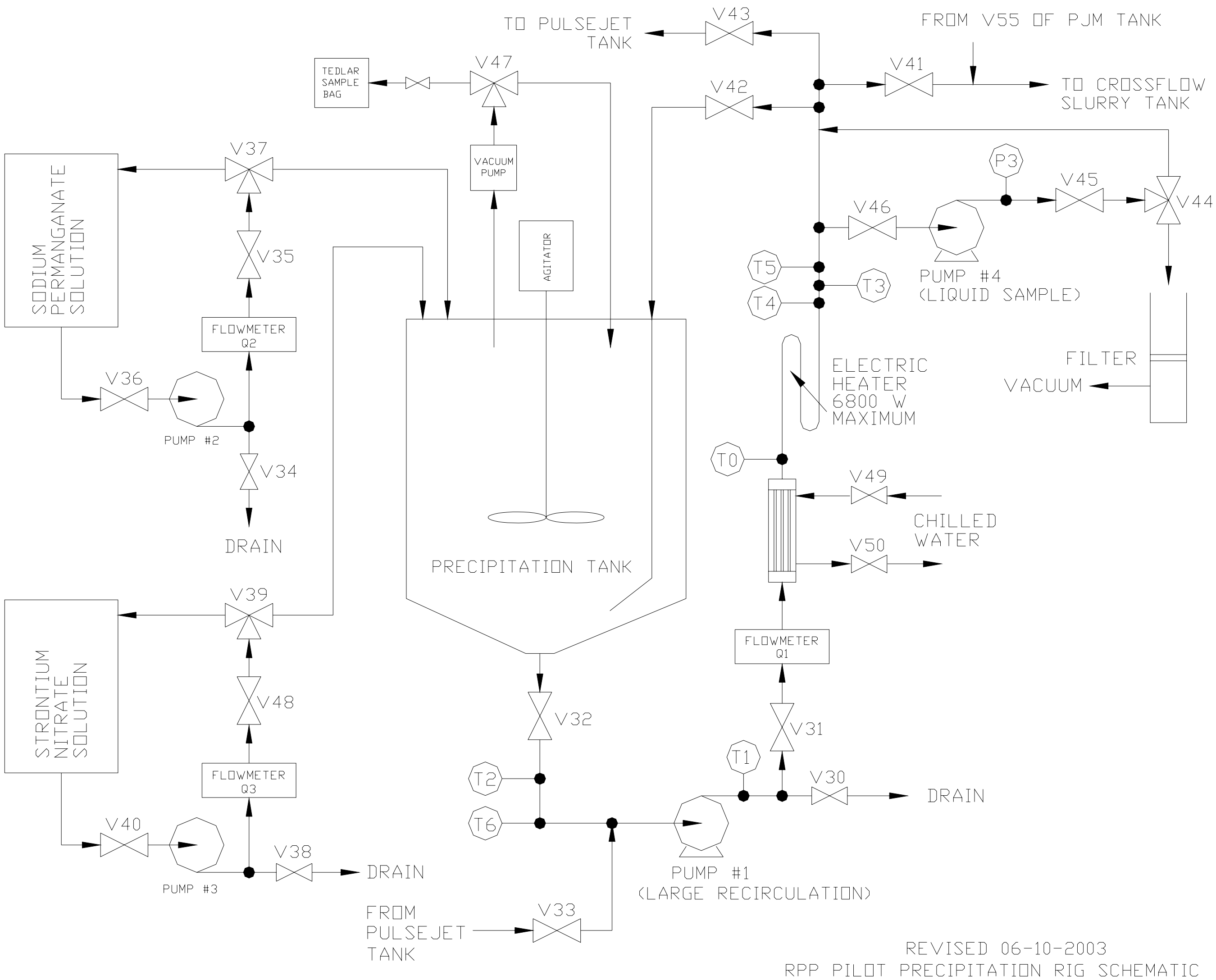

Figure 3-1. Mechanically Agitated Pilot-Scale Precipitation Test Rig

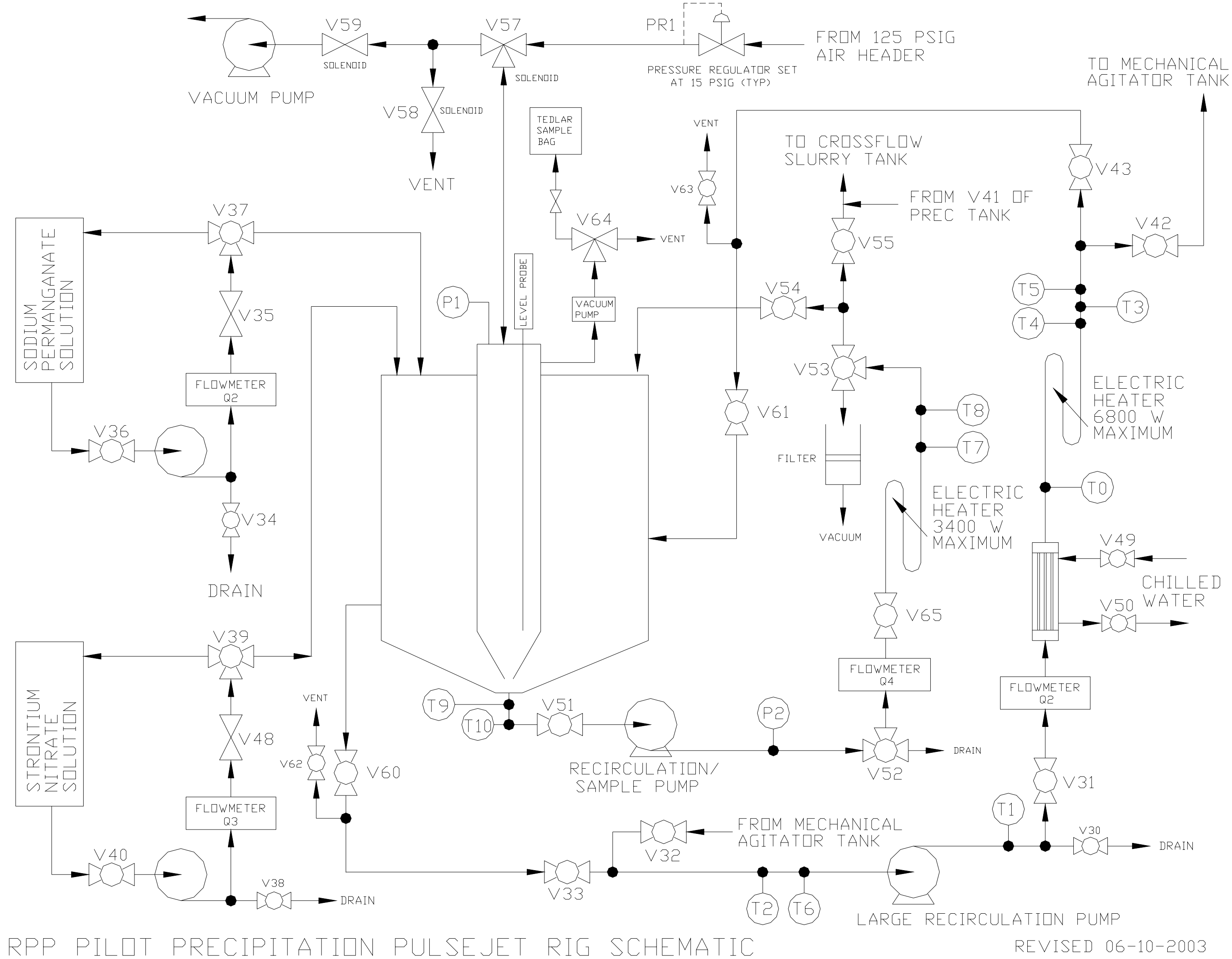

Figure 3-2. Pulse-Jet-Mixed Pilot-Scale Precipitation Test Rig

Dilution water was manually poured through an access port in the mechanically agitated tank cover or into the open top of the pulse jet mixed tank. Sodium hydroxide as either solid beads or 50 wt% solution was also added directly to the mechanically agitated tank through the access port when caustic adjustment was made as shown in the test matrix. For the pulse jet mixed tank the sodium hydroxide was gravity fed from an overhead carboy to the open top of the tank at the scaled prototypic addition rate. (When 50 wt% sodium hydroxide was used the dilution water was decreased accordingly to allow for the water content.)

An individual addition system including a tank, recirculation pump, and flowmeter was provided for each of the reagents. The sodium permanganate tank is opaque because the reagent is light sensitive. Typically, the reagents were mixed in the tanks by recirculating the solution at the desired flow rate. Then the aqueous solution was valved over to the precipitation tank for addition. The strontium nitrate was added first and allowed to mix throughout the tank before adding the sodium permanganate. For the first two batches the sodium permanganate was not standardized, but was prepared from new, sealed regent stock immediately prior to use. For the later batches, the sodium permanganate was standardized prior to use and the flow rate adjusted slightly to compensate for reagent strength. (Little variation in reagent strength was found when it was stored in the opaque, closed reagent tank for a week or so.)

A sample of the mechanically agitated precipitation tank contents could be drawn off with a pump connected to the main recirculation loop. The take-off from the recirculation line was a thin-wall, small-diameter tube about a foot long installed concentrically inside the recirculation pipe and pointing into the flow. The tube and recirculation pipe were sized to have identical flow velocities at a recirculation flowrate of 9.64 gpm and a sample rate of one liter every 20 seconds. Typically, flow was established through the sample pump and returned to the recirculation loop to ensure the line was full and flushed with fresh material. The flow was then quickly valved to the collection container, then valved back to the recirculation loop when approximately one liter of sample was collected. Trial runs were used to preset throttle valve V45 to deliver one liter in 20 seconds. Some slurry samples were submitted directly for certain analysis, others were dead-end filtered to separate the solids from the liquid portion for separate analysis. For the pulse jet mixed tank the prototypical recycle flow was small enough that it could be valved completely to the container for sample collection.

The mechanically agitated tank had a cover that rests on a lip at the top of the tank with only a small annulus opening around the agitator shaft. (The previously mentioned access port was covered when not in use.) A diaphragm pump was connected to a tube that passed through the cover to within six inches of the liquid surface. The discharge of the vapor sampling pump was connected to a 3-way valve with tubing leading to a sample port or back to the tank vapor space. Flow was normally routed from the vapor space through the pump and returned to the vapor space to keep the lines flushed. Either a sample syringe or flattened Tedlar sample bag could be connected to the sample port through its own isolation valve.

When a sample was desired the sample container isolation valve was opened, the three-way valve was switched to the port, the pump filled the container, the 3-way valve was switched back to the vapor space, and the sample container isolation valve was closed. The sample port was very close-coupled to the 3-way valve to minimize contamination of the sample with ambient air. For Batch 4, the vapor sampling system was relocated to the pulse jet mixed tank with connections made to draw the sample from the interior of the pulse jet tube.

3.4.2 Pulse Jet Mixer

The pulse jet mixer used a pulse of pressurized air to force liquid rapidly out through a nozzle at the bottom, then refilled due to the difference in hydrostatic pressure inside and outside the partially empty tube. A vacuum could be applied to speed up the refill, or to raise the level inside the tank above the outside level providing a larger pulsed volume. The discharge/refill cycle was repeated at some regular frequency to mix the tank contents.

The pulse jet drive is shown in Figure 3-2. Compressed air was supplied from a large 125-psig plant air header through 1” S/S tubing, through a pressure regulator to reduce and stabilize the pressure, and through a 3-way solenoid valve to a 1” NPT port on top of the pulse jet. The other port of the 3-way solenoid valve could be either simply vented, or connected to a blower capable of exhausting large quantities of air at a maximum 60-inch water vacuum. The vent and blower lines had individual solenoid valves for control selection purposes. A capacitance-type level probe sent the level inside the pulse jet to a control computer.

The control computer switched the 3-way solenoid valve to the air supply until the liquid level dropped to the specified level, then switched the 3-way solenoid valve to the vacuum/vent line and opened the vacuum solenoid until the level rose to the specified level, then closed the vacuum and opened the vent solenoid valves until time to repeat the entire cycle. When the 3-way valve was switched to apply vacuum, the level in the pulse jet did not immediately stop dropping. The air inside the pulse jet continued to expand and discharge the liquid until the combination of increasing air volume and air being removed by the vacuum pump lowered the pressure below that of the outside liquid. Likewise, the level did not stop rising immediately when the vacuum was shut off and the system vented. If the total cycle time was too short, the level in the pulse jet could not reach equilibrium with the outside tank level. (This was still a stable operating mode, however.) If the pressure stop level was set too low, the pulse jet emptied completely, and the remaining air blew out with an audible boom and considerable tank vibration.

The length of time the 3-way valve was switched to the air supply, or drive time, was displayed for each cycle by the computer. The pressure-drive stop level, vacuum refill stop level, and overall cycle time could be changed at any time during operation. Changing these settings allowed the drive time and percent pulsed to be adjusted as desired. The computer logged these settings and the status of the solenoid valves. Also logged were the pulse jet interior pressure, pulse jet interior liquid level, recycle flow rate, tank exit temperature, and heater exit temperature.

Although not logged directly, the length of the drive pulse could be determined if the data logging rate was very rapid. The data logging rate could be changed at any time. The regulator output pressure was adjusted manually and the setting recorded in the task logbook.

The dimensions and other details of the pulse jet and tank used for Batch 4A are shown in Figure 3-3. At the request of the customer, the pulse jet was made essentially identical in size to one used in previous studies by others. A one-to-one height-to-diameter ratio after reagent addition was specified to match the ratio in the plant design. Finally, the pulse jet was to pulse about 6% of the tank liquid volume. These requirements fixed the dimension shown, along with the batch size of 572 liters.

High air flow rates were required to meet the short discharge time required for Batch 4A mixing (1.6-second drive time). We used a ¾" body size Fisher 95L regulator with adjustment springs sized for 13 to 30 psig operation. This regulator could deliver 133 scfm @ 20 psig from a 100 psig supply with only a 10% offset. The 3-way solenoid valve was an ASCO 8316G34 (1" NPT ports, 1" orifice, 12.5 Cv). The 2-way solenoid valves were older models we had on hand. The normally closed vacuum valve was equivalent to the currently available ASCO 8210G95 (3/4" NPT ports, 3/4" orifice, 5.0 Cv); the normally open vent valve was equivalent to the currently available ASCO 8210G35 (3/4" NPT ports, 3/4" orifice, 5.5 Cv). We used a GAST Mfg Corp. Regenair R5325A-2 blower (2.5 hp, 145 cfm open flow, maximum 60 inches water vacuum).

3.4.3 Pilot-Scale Crossflow Filter Test Rig Description

Figure 3-4 is the schematic of an existing Pilot-Scale Crossflow Filter Test Rig that was located in the rear of the Engineering Development Laboratory, Building 786-A. The filter and most of the 300 series stainless steel piping used for the rig was still in place from previous testing by Duignan (17). The slurry loop pumps, some instrumentation, and other minor equipment had been removed from the rig for reuse on other tasks and had to be replaced. Otherwise, only relatively minor alterations were needed for these tests.

For Batches 1 and 2, PVC and CPVC plastic pipe were used to quickly connect two 3-hp stainless steel centrifugal pumps in place of the three pumps previously used. Although these pumps were not built specifically to handle slurry, they had proved adequate in the past for low wt% solid slurries. (Their primary drawback was the need for frequent seal replacement when used with high wt% solid slurries.) The decision to concentrate the slurry to the maximum wt% possible for Batch 2 (gaining important filtration data) caused the pump seals to become the limiting factor during filtration. We also were unable to provide adequate cooling of the slurry at the maximum flow and maximum transmembrane pressure desired. Finally, maturing plant design led to the decision to replace the filter with a larger unit requiring more pumping power to operate.

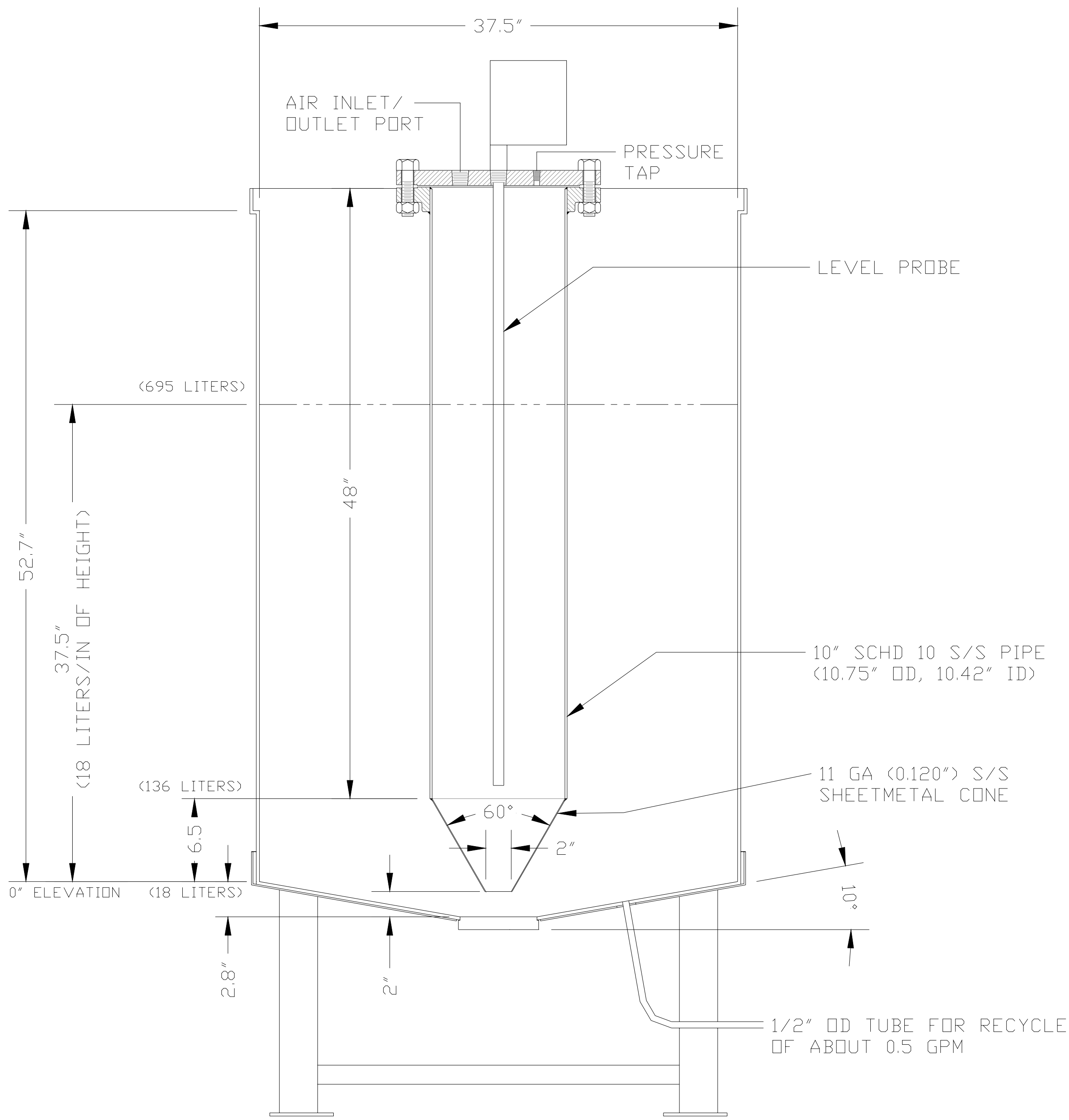

Figure 3-3. Pulse Jet and Tank Details

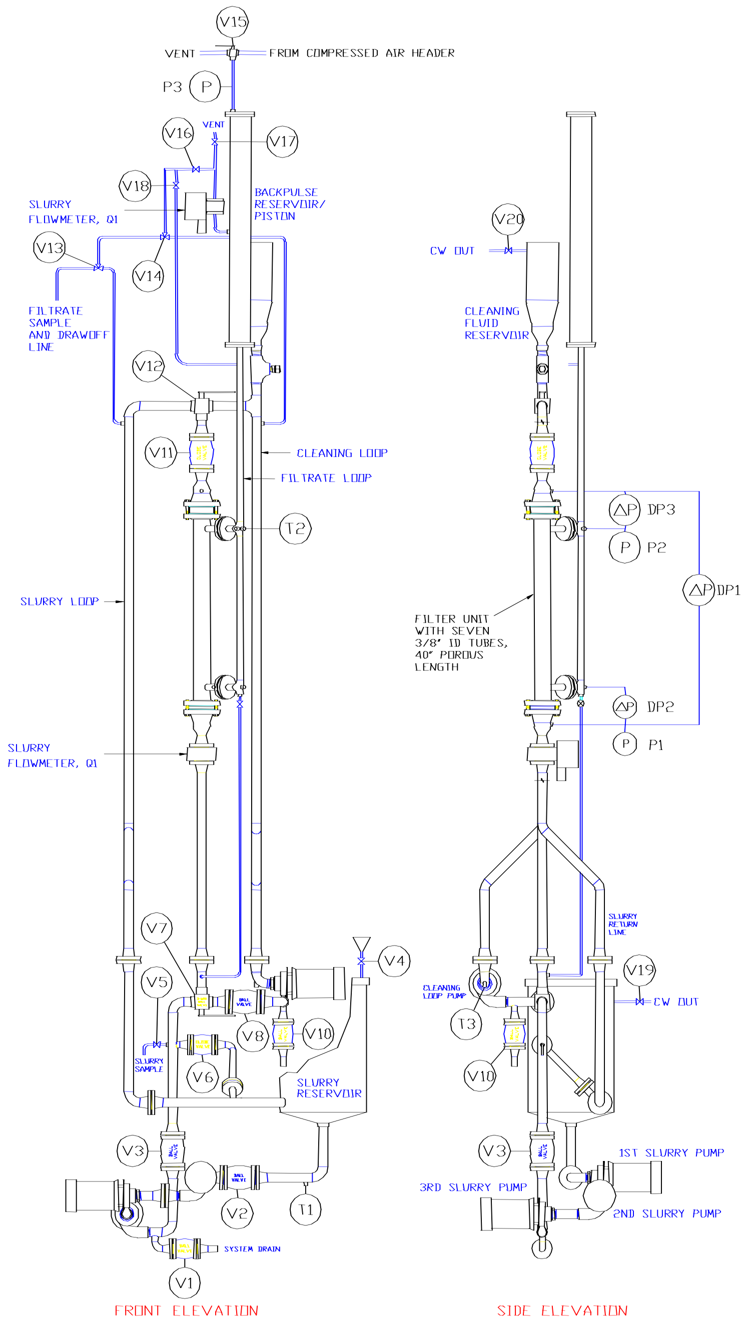

Figure 3-4. Pilot-Scale Crossflow Filter Test Rig

For Batches 3 and 4, the pumps were replaced by larger, slurry rated EPDM lined centrifugal pumps installed with 304 stainless piping. The new pumps incorporated double mechanical shaft seals with pressurized water between them. A closed loop seal water system (not shown in the schematic) consisting of a pump, tank, and cooling coil was installed for these two slurry pumps and the large recirculation loop pump on the precipitation rig. Throttle valves and rotameters were provided at each pump to allow appropriate setting of flow and pressure to the seals. During shakedown, the 5-hp, 208V, 3-phase motors originally provided for these new pumps were shown to be slightly undersized and unable to simultaneously provide the maximum flowrate at the maximum transmembrane pressure desired while using the larger filter. The motors were replaced with 10-hp, 480V, 3-phase motors. A heat exchanger was installed in the slurry loop to provide the necessary cooling for the high flow, high transmembrane pressure test matrix points.

For all batches, the slurry pump motors were manually controlled by variable frequency drives, providing excellent control of the flow.

The rig is approximately 25 feet tall and is serviced by a two-level mezzanine. The Crossflow Test Rig is made up of three basic flow loops:

- Slurry loop, which contains the two centrifugal pumps previously described, flowmeter, throttle valve, and crossflow filter. This loop serves as the primary flow path for circulating slurries. This loop has an internal volume of approximately 20 liters, excluding the slurry reservoir.
- Filtrate loop, which begins at the filter housing and allows the separated filtrate liquid to flow up through the backpulse system before returning to the top of the slurry loop to close the circuit. This loop has an internal volume of approximately six liters. Note that this loop has a three-way valve that can be positioned to draw off the filtrate to a collection tank rather than returning it to the slurry loop. This option is used during dewatering to concentrate the slurry.
- Cleaning loop, which enables cleaning of the crossflow filter in place without having to remove the slurry from the test rig. This loop has an internal volume of approximately 15 liters and contains its own a 3-hp centrifugal pump.

Two other flow circuits that are subsections of the other loops are the backpulse and the bypass loops:

- The backpulse loop is part of the filtrate loop and functions to reverse the flow of filtrate back through the filter. A pulse forces filtrate back through the filter elements in order to knock off built-up slurry cake on the inside diameter of the porous tubes.

  For Batches 1 and 2, an air-driven backpulse piston assembly controlled the amount of filtrate used for a backpulse. The piston was adjusted to deliver a constant pressure pulse of 0.036 gal per ft^2 of filter tube inside surface area. This pulse was sufficient to generate a significant improvement in filtrate flux immediately following a backpulse generated by opening the V15 valve. The filtrate flow was interrupted for only about ten seconds during the backpulse operation. (The actual backpulse had a duration of only a few seconds.)

  For Batches 3 and 4, the backpulse piston was replaced with a system more prototypical of the plant design. The new system used a flow-through pulsepot that could be isolated and pressurized with air just prior to backpulsing. When the pressurized pot was valved back to the crossflow filter housing, there was an initial high pressure pulse with a rapidly increasing flow. As the air in the pot expanded and dropped in pressure, the flow rate peaked then gradually dropped off to zero. A detailed discussion of the design and operational experience with this backpulse system is covered in a separate crossflow filter report (Duignan, 21) so it won't be discussed further in this report.

- The bypass loop is part of the slurry loop and routes part of the flow through valve V6 back to the reservoir. This loop was used to better control the slurry flow during slurry pump startup, improve mixing, and ensure the slurry remained well-mixed when the flow through the filter needed to be stopped.

The slurry reservoir is a 110-liter plastic tank that receives feed from the RPP Pilot Precipitation System. When necessary, direct addition to the slurry reservoir was made via the funnel attached to the V4 valve. The precipitated waste simulant in the slurry reservoir was kept well mixed utilizing the slurry pumps in the slurry loop drawing from the bottom of the tank.

3.4.4 Crossflow Filter

The crossflow filter is the primary component in the Crossflow Test Rig, used to establish filterability of the precipitate and associated operational characteristics under various flow conditions. Successful past operating experience (9), similarity to the planned RPP filter, and availability dictated the utilization of an existing Mott crossflow filter for Batches 1 and 2. The specifications for the filter unit tubes were:

Material	316 stainless steel (sintered metal)
Porosity	nominal rated 0.1 micron
Length	40 inches
Diameter	$^{3}/_{8}$-inch ID, $^{1}/_{2}$-inch OD
Number of tubes	7

This filter is thoroughly described in Reference 9.

Plant design had matured while Batch 1 and 2 testing was being conducted, and we were asked to replace this filter with a similar but larger filter for Batches 3 and 4. The new Mott filter also had seven nominal rated 0.1 micron porous tubes, but the tubes were $^{1}/_{2}$-inch ID, $^{5}/_{8}$-inch OD, and 90 inches long. This filter is thoroughly described in a separate crossflow filter report (Duignan, 21) so it won't be discussed further in this report.

3.4.5 Instrumentation and Data Acquisition System

Most of the data collected during the precipitation reaction was recorded by either the Pilot Scale Precipitation Data Acquisition System (PSP DAS) as listed in Table 3-1 or the Pulse jet Mixed Tank Data Acquisition System (PJM DAS) as listed in Table 3-2. A few instruments were not connected to either DAS, so their readings were recorded manually in the logbook when appropriate.

A specific gravity hydrometer was used to measure the ratio of the density of the slurry sample compared to the density of pure water at 60 ^{o}F (15.6 ^{o}C) with a range of 1.000 to 1.600 g/ml and an accuracy of $\pm$0.005 g/ml. Readings from this instrument were recorded manually.

A variable frequency drive (VFD) was provided for the agitator with a range of 60 to 550 rpm with 5% accuracy. The speed was set manually and recorded in the logbook.

A VFD was also used with the large recirculation loop pump setup for 0 to 60 Hz with a stated accuracy of 0.010 Hz. A PID control loop on the DAS takes input from magnetic flow meter TR-03661 and outputs a signal to this VFD to control flow in the range of 0 to 50 gpm. Although the VFD setting was not recorded, the measured flow was recorded by the DAS as noted in Table 3-1.

Table 3-1. PSP DAS Channel List for Pilot-Scale Precipitation Test Facility

Chan	Instrument Label	Instrument Location	Range	Uncertainty	M&TE Number
0	HX Outlet TC T0	HX OUTLET	0 to 100°C	$\pm$1.1°C	TR-02953
1	Recirc Pump Outlet TC T1	PUMP DISCH	0 to 100°C	$\pm$1.2°C	TR-02948
2	Tank Bottom TC T2	TANK	0 to 100°C	$\pm$1.3°C	TR-02947
3	Heater Outlet TC T3	HEATER OUT	0 to 100°C	$\pm$0.9°C	TR-02955
6	Recirc Pump Flow Q1	RECIRC FLOW	0-50gpm	$\pm$0.2 gpm	TR-03661
7	$NaMnO_4$ Tank Flow Q2	REAGENT FLOW1	0-5gpm	$\pm$0.3 gpm	TR-03563
8	$Sr(NO_3)_2$ Tank Flow Q3	REAGENT FLOW2	0-6.2gpm	$\pm$0.02 gpm	TR-03670
9	Ammeter	TEMPERATURE CONTROLLER	0-200 amps	*	3-1982
10	Voltmeter	TEMPERATURE CONTROLLER	0-200 volts	*	3-1981

***** Uncertainty not determined. The ammeter and voltmeter information were recorded in the raw PSP DAS data simply to show when the heater was on or off.

Table 3-2. PJM DAS Channel List for Pulse jet Mixed Tank

Chan	Instrument Label	Instrument Location	Range	Uncertainty	M&TE Number
0	Pulse jet tube pressure P1	Pulse jet Flange	-3 to +24 psid	$\pm$0.08 psid	TR-03496
1	Pulse jet level L1	Inside Pulse jet	0 to 48”	$\pm$0.14”	TR-03686
2	Recirc Pump Flow Q4	RECIRC FLOW	0-1.6 gpm	$\pm$0.02 gpm	TR-03680
3	Tank Bottom TC-T10	TANK	0 to 100°C	$\pm$1.6°C	TR-01517
4	Heater Outlet TC-T8	HEATER OUT	0 to 100°C	$\pm$1.6°C	TR-02973

The uncertainty introduced through the use of the 16-bit data acquisition systems (DAS) was insignificant (<0.1% reading) and was not included in Table 3-2 values.

There was a temperature controller that could be connected either to the 6.8 kw heater or the 3.6 kw heater as required. It was controlled based on the output from an uncalibrated type E thermocouple, and had a safety shutdown based on the output from a separate uncalibrated type E thermocouple. Although the settings on this controller were not recorded, the actual temperature of the tank measured by calibrated thermocouples was recorded as noted in Table 3-1.

Most of the measurement equipment used to collect data during filtration was recorded by the Crossflow Data Acquisition System (Xflow DAS) as listed in Table 3-3 and Table 3-4.

Table 3-3. Xflow DAS Channel List for Crossflow Filter Test Rig During Batches 1 and 2

Chan	Instrument Label	Instrument Location	Range	Uncertainty	M&TE Number
D I/O	V15 Solenoid	Solenoid Control	Open or closed	N/A	Solenoid
0	Filtrate TC T2	FLTRT (^{o}C)	0 to 100 ^{o}C	±1.0 ^{o}C	TR-02927
1	Cleaning Loop TC T3	CL LOOP (^{o}C)	0 to 100 ^{o}C	±1.2 ^{o}C	TR-02930
2	Slurry Loop TC T1	SL LOOP (^{o}C)	0 to 100 ^{o}C	±1.4 ^{o}C	TR-02929
3	Upper Ambient TC T4	UP AMB (^{o}C)	0 to 100 ^{o}C	±1.3 ^{o}C	TR-02925
4	Bottom Ambient TC T5	BOT AMB (^{o} C)	0 to 100 ^{o}C	±1.4 ^{o}C	TR-02926
6	Bottom DP DP2	BOT DP (psid)	0-100 psid	±0.1 psid	TR-00532
7	Filter Pressure-P1	FLTR (psig)	0-100 psig	±0.1 psig	TR-02917
8	Filter DP-DP1	FLTR DP (psid)	0-26 psid	±0.03 psid	TR-03495
9	Top DP-DP3	TOP DP (psid)	0-100 psid	±0.8 psid	TR-03115
10	Filtrate Pressure P2	FLTRATE (psig)	0-91 psig	±0.2psig	TR-03109
11	Piston Pressure P3	PISTON (psig)	0-151 psig	±0.3 psig	TR-02145
12	Filter Flow Q2	FLTR FLOW (gpm)	0-1.21 gpm	±0.01 gpm	TR-20353
13	Slurry Flow Q1	SL FLOW (gpm)	0-100 gpm	±0.4 gpm	TR-20350
14	HI Filter Flow Q3	FLTR FLOW (gpm)	0-5 gpm	±0.01gpm	TR-03562

Table 3-4. Xflow DAS Channel List for Crossflow Filter Test Rig During Batches 3 and 4

Chan	Instrument Label	Instrument Location	Range	Uncertainty	M&TE Number
D I/O	V15 Solenoid	Solenoid Control	Open or closed	N/A	Solenoid
0	Filtrate TC T2	FLTRT (^oC)	0 to 100 ^oC	$\pm$1.0 ^oC	TR-02927
1	Cleaning Loop TC T3	CL LOOP (^oC)	0 to 100 ^oC	$\pm$1.0 ^oC	TR-02930
2	Slurry Loop TC T1	SL LOOP (^oC)	0 to 100 ^oC	$\pm$0.9 ^oC	TR-02929
3	Upper Ambient TC T4	UP AMB (^oC)	0 to 100 ^oC	$\pm$1.0 ^oC	TR-02925
4	Bottom Ambient TC T5	BOT AMB (^{o} C)	0 to 100 ^oC	$\pm$1.0 ^oC	TR-02926
6	Bottom DP DP2	BOT DP (psid)	0-100 psid	$\pm$0.11 psid	TR-03553
7	Filter Pressure-P1	FLTR (psig)	0-100 psig	$\pm$0.1 psig	TR-02917
8	Filter DP-DP1	FLTR DP (psid)	0-26 psid	$\pm$0.045 psid	TR-03495
9	Top DP-DP3	TOP DP (psid)	-11-91 psid	$\pm$0.14 psid	TR-03109
10	Filtrate Pressure P2	FLTRATE (psig)	0-151 psig	$\pm$0.39psig	TR-03115
11	Piston Pressure P3	PISTON (psig)	0-151 psig	$\pm$0.18 psig	TR-00532
12	Filter Flow Q2	FLTR FLOW (gpm)	0-1.21 gpm	$\pm$0.01 gpm	TR-20353
13	Slurry Flow Q1	SL FLOW (gpm)	0-100 gpm	$\pm$0.5 gpm	TR-20350
14	HI Filter Flow Q3	FLTR FLOW (gpm)	0-5 gpm	$\pm$0.02gpm	TR-03562
15	Quickpulse Q4	BACKPULSE FLOW (gpm)	0-5 gpm	$\pm$0.02gpm	TR-03276

Instruments not connected to the Xflow DAS, but used during the experiment include the following:

- A Type J thermocouple with accuracy of 1.1 ^oC used for the Sample Drying Oven with local indication
- A VFD for each Slurry Pump manually controlled from 0 to 60 Hz with an accuracy of 0.010 Hz

The uncertainties in the instrument readings were based on multiple point calibrations with reference standards. Calibration sheets are included in the task logbook (4).

The velocity through the crossflow filter tubes is calculated based on the slurry loop flow measured by magnetic flowmeter Q1 divided by the cross-sectional area of seven tubes with 3/8" nominal ID. The uncertainty in this calculated value is the combination of the instrument uncertainty and the uncertainty in the flow area. A typical flow in the slurry loop exceeds 10 gpm. The uncertainty in the instrument is therefore ±3.6% or less. An accurate measurement of the average inside diameter of the filtrate tubes was impossible since it may vary down the length of each filter tube and may vary from tube to tube. Even measuring the diameter at the filter tube ends is difficult because of the weldments to the tube sheets. For these reasons, the uncertainty in flow area will be based on the manufacturer's stated tolerances. For a Mott 3/8" tube the diameter tolerances are stated to be +0.025 inch and –0.005 inch. The diameter of the filter tubes can presumably vary anywhere between those tolerances; therefore, for this task the diameter uncertainty will be taken as ±0.015 inch, or 4% of the nominal diameter. The combined uncertainty is (3.6%^2 + 4.0%^2)^1/2 = ±5.4%.

The transmembrane pressure is calculated by averaging the differential pressure between the slurry side and the filtrate side at the top (DP3) and bottom (DP2) of the filter. The uncertainty for these instruments at about 40 psid is 0.74 psid or about ±1.8%. The combined uncertainty would be about (1.8%^2 + 1.8%^2)^1/2 = ±2.5%.

The filtrate flow is calculated based on either magnetic flowmeters Q2 or Q3, depending on the range of flow, divided by the inside surface area of the filtrate tubes. A typical flow rate is 0.5 gpm. The instrument uncertainty is about ±0.014 gpm, or ±2.8%. The uncertainty of the inside diameter of the filter tubes has already been addressed above. The uncertainty of the length of the filter tubes was estimated from in-house measurements as ±1/8 inch, or ±0.3% of the nominal 40" length. The combined uncertainty is about (2.8%^2 + 4.0%^2 + 0.3%^2)^1/2 = ±4.9%.

3.5 SIMULATED WASTE DESCRIPTION

3.5.1 AN-107 Simulant

Approximately 650-liter volumes of Envelope C (Eibling and Nash, 15) Tank AN-107 simulant were used for the initial feed of Batch 1 and 2. The non-radioactive AN-107 simulant recipe was chemically similar to the radioactive waste characterized in Hanford Tank AN-107 and included transition metals, complexing agents, other organic compounds and entrained solids. An approved recipe from Eibling and Nash (15) was used per the Task Plan (1).

Optima Chemical was selected as the vendor to supply 1300 liters of AN-107 simulant supernate according to the recipe shown in Table 3-5. A miscommunication in the form (hydrated vs. anhydrous) of sodium EDTA specified resulted in the partial simulant obtained from Optima containing 12% more sodium EDTA than desired. (See Appendix A for a more complete explanation.) Small deviations in the water content caused the volume to be about 1.5% less than specified resulting in correspondingly higher density and chemical concentrations.

Table 3-5. AN-107 Recipe Quantities Before Precipitating Reagents Added

AN-107 Supernate Simulant (based on AN-107; Sr/Tru C-5.5M recipe)								
Vessel 1			Recipe amounts for 1300 liters					
			Compound	Water	Non-water			Na Content, grams
Compounds	Formula	Formula Weight	mass, grams	mass, grams	mass, grams	Conc., mg/mL	Conc., Molar	
Water charged to tank			260000.00	260000.00				
Calcium Nitrate	$Ca(NO_3)_2.4H_2O$	236.15	2838.93	865.56	1973.36	1.518	0.00925	
Cerium Nitrate	$Ce(NO_3)_3.6H_2O$	434.22	133.40	33.18	100.22	0.077	0.00024	
Cesium Nitrate	$CsNO_3$	194.91	22.25		22.25	0.017	0.00009	
Copper Nitrate	$Cu(NO_3)_2.3H_2O$	241.6	93.30	20.85	72.45	0.056	0.00030	
Ferric Nitrate	$Fe(NO_3)_3.9H_2O$	403.99	9967.23	3996.86	5970.37	4.593	0.01898	
Lanthanum Nitrate	$La(NO_3)_3.6H_2O$	433.01	115.64	28.84	86.80	0.067	0.00021	
Lead nitrate	$Pb(NO_3)_2$	331.2	505.64		505.64	0.389	0.00117	
Magnesium Nitrate	$Mg(NO_3)_2.6H_2O$	256.41	215.02	90.57	124.45	0.096	0.00065	
Manganous Chloride	$MnCl_2.4H_2O$	197.9	1653.44	601.55	1051.89	0.809	0.00643	
Neodymium Nitrate	$Nd(NO_3)_3.6H_2O$	438.34	237.60	58.54	179.06	0.138	0.00042	
Nickel Nitrate	$Ni(NO_3)_2.6H_2O$	290.81	2141.06	795.14	1345.92	1.035	0.00566	
Potassium Nitrate	KNO_3	101.11	3754.22		3754.22	2.888	0.02856	
Strontium Nitrate	$Sr(NO_3)_2$	211.63	13.01		13.01	0.010	0.00005	
Zinc Nitrate	$Zn(NO_3)_2.6H_2O$	297.47	168.04	61.01	107.03	0.082	0.00043	
Zirconyl Nitrate	$ZrO(NO_3)_2.XH_2O$	249.23	155.92	11.27	144.65	0.111	0.00048	
EDTA	Na_2EDTA	372.24	5917.79	572.32	5345.47	4.112	0.01223	809
HEDTA	HEDTA	278.26	1763.87		1763.87	1.357	0.00488	
Sodium Gluconate	$CH_2OH(CHOH)_4COONa$	218.14	3201.21		3201.21	2.462	0.01129	337
Glycolic Acid	$HOCH_2COOH$	76.05	21954.11		21954.11	16.888	0.22206	
Citric Acid	$HOC(CH_2CO_2H)_2CO_2H$	192.13	7696.54		7696.54	5.920	0.03081	
Nitrilotriacetic Acid	$N(CH_2COOH)_3$	191.14	464.72		464.72	0.357	0.00187	
Iminodiacetic Acid	$HN(CH_2CO_2H)_2$	133.1	4923.03		4923.03	3.787	0.02845	
Boric acid	H_3BO_3	61.83	163.21		163.21	0.126	0.00203	
Sodium Chloride	$NaCl$	58.44	1482.80		1482.80	1.141	0.01952	583
Sodium Fluoride	NaF	41.99	239.66		239.66	0.184	0.00439	131
Sodium Chromate	Na_2CrO_4	161.97	446.98		446.98	0.344	0.00212	127
Sodium Sulfate	Na_2SO_4	142.04	9945.79		9945.79	7.651	0.05386	3220
Potassium Molybdate	K_2MoO_4	238.14	72.45		72.45	0.056	0.00023	
Total Weights in vessel 1			340286.84	267135.70	73151.15			5208
Vessel 2 (added to contents of vessel 1 after mixing)			Recipe amounts for 1300 liters					
			Compound	Water	Non-water			Na Content, grams
Compounds	Formula	Formula Weight	mass, grams	mass, grams	mass, grams	Conc., mg/mL	Conc., Molar	
Water charged to tank			260000.00	260000.00				
Sodium Hydroxide	$NaOH$	40	20596.52		20596.52	15.843	0.39609	11838
Aluminum Nitrate	$Al(NO_3)_3.9H_2O$	375.13	4375.31	1889.48	2485.83	1.912	0.00897	
Sodium Phosphate	$Na_3PO_4.12H_2O$	380.12	3622.08	2058.22	1563.86	1.203	0.00733	657
Sodium Formate	$NaHCOO$	68.01	12809.40		12809.40	9.853	0.14488	4330
Sodium Acetate	$NaCH_3COO.3H_2O$	136.08	1931.56	766.49	1165.07	0.896	0.01092	326
Sodium Oxalate	$Na_2C_2O_4$	134	1025.21		1025.21	0.789	0.00589	352
Sodium Carbonate	Na_2CO_3	105.99	120865.25		120865.25	92.973	0.87719	52433
Water used to clean vessel 2 & flush hose								
Total added from vessel 2			425225.33	264714.19	160511.14			69936
Vessel 3 (added to combined vessel 1 and 2 after mixing)			Recipe amounts for 1300 liters					
			Compound	Water	Non-water			Na Content, grams
Compounds	Formula	Formula Weight	mass, grams	mass, grams	mass, grams	Conc., mg/mL	Conc., Molar	
Water charged to tank			130000.00	130000.00				
Sodium Nitrate	$NaNO_3$	84.99	242371.35		242371.35	186.440	2.19366	65562
Sodium Nitrite	$NaNO_2$	69.00	74589.14		74589.14	57.376	0.83154	24852
Water used to clean vessel 3 & flush hose								
Water added at end to bring volume up to total			404364.00	404364.00				
Total added to previous mixture			851324.49	534364.00	316960.49			90414
Overall totals			1616836.66	1066213.88	550622.78			165558
Volume, ml			1300000.00					
Calculated density, gm/ml			1.2437					

Table 3-5. AN-107 Recipe Quantities Before Precipitating Reagents Added - continued

Complete AN-107 Simulant before reagent addition								
Entrained Solids and Perrhenate added in EDL (1)			Recipe amounts for 650 liters					
			Compound	Water	Non-water			
Compounds	Formula	Formula Weight	mass, grams	mass, grams	mass, grams	(3) Conc., mg/mL	(3) Conc., Molar	Na Content, grams
Sodium Perrhenate	$NaReO_4$	273.2	11.16		11.16	0.017	0.00006	1
Aluminum Oxide (2)	Al_2O_3	101.96	225.30		225.30	0.347	0.00340	
Calcium Phosphate	$Ca_3(PO_4)_2$	310.18	2.93		2.93	0.005	0.00001	
Chromic Oxide	Cr_2O_3	151.99	15.47		15.47	0.024	0.00016	
Ferric Oxide	Fe_2O_3	159.69	192.75		192.75	0.297	0.00186	
Manganese Dioxide	MnO_2	86.94	124.78		124.78	0.192	0.00221	
Silicon Dioxide (2)	SiO_2	60.09	21.10		21.10	0.032	0.00054	
Sodium Oxalate	$Na_2C_2O_4$	134	1381.39		1381.39	2.125	0.01586	474
Sodium Carbonate	$Na_2CO_3.H_2O$	124.01	1306.38	189.62	1116.76	1.718	0.01385	484
Sodium Fluoride	NaF	41.99	202.10		202.10	0.311	0.00740	111
Sodium Sulfate	$Na_2SO_4.10H_2O$	322.2	166.97	93.28	73.69	0.113	0.00035	24
Sodium Phosphate	$Na_3PO_4.12H_2O$	380.12	373.97	212.51	161.46	0.248	0.00065	68
Total EDL additions to supernate simulant, grams			4024.30	495.41	3528.89			1162
Mass of supernate simulant used per batch, grams			808418	533107	275311			82779
Volume of supernate simulant used, ml			650000					
Sodium molarity of supernate simulant								5.54
Total supernate simulant and EDL additions, grams			812443					83941
Calculated density of final simulant (neglecting small volume increase due to adding solids), gm/ml			1.2499					
Notes: (1)	All solids added were less than or equal to 5 microns in size							
(2)	The recipe specified 0.1754 moles of sodium aluminosilicate, $Na_2.Al_2O_3.(SiO_2)_2.5H_2O$ that was unavailable from suppliers. The author of the recipe was contacted and recommended the substitution of 2*0.1754 = 0.3058 moles = 21.08 grams of SiO2 and 0.1754 moles = 17.88 grams of Al_2O_3 instead. The 17.88 grams of Al_2O_3 was added to the 207.38 grams Al_2O_3 in the original entrained solids recipe for a total of 225.26 grams Al_2O_3 to be added.							
(3)	An error was made when the recipe concentrations were reported in the previous interim reports. The concentrations had been calculated using the double batch size of 1300 liters rather than the half batch size of 650 liters.							

Entrained solids (0.5 w%) and sodium perrhenate were added to the purchased partial supernate simulant in the Precipitate Tank at the EDL to complete the AN-107 simulant. The recipe for the EDL additions is included in Table 3-5.

3.5.2 AN-102 Simulant

Originally several tests were planned using Envelope C Tank AN-102 simulant. A recipe was developed by Eibling based on Chemical Characterization of an Envelope C Sample from Hanford Tank 241-AN-102 (22) and approved for use. Optima Chemical was selected as the vendor to supply 4700 liters of the supernate; EDL would add the entrained solids shortly before adding the reagents.

To develop a simulant, small samples of the actual radioactive waste are collected and analyzed. Generally, the analyses of multiple samples do not agree completely, and an average composition is determined. The types and amounts of inorganic salts are determined to provide the proper mix of elements. Some compromise must be made because the final solution cannot contain an excess of either positive or negative ions, the charges must balance. Balancing the charges is most easily done by making a small adjustment in the amount of some cation that is present in a large amount. This technique generally minimizes the impact on the simulant properties. In the original simulant development the decision was made to balance the charges by adjusting the carbonate content.

During one of the pilot precipitation review meetings there was considerable discussion of the simulant factoring in results of ongoing research at other sites. These discussions concluded that the amount of carbonate in the simulant could be a more significant factor during precipitation than originally thought. It was decided to rework the recipe, balancing the charges by adjusting the nitrite and nitrate concentrations rather than the carbonate concentration. A new recipe was developed by Eibling (23) and approved as AN-102 R2 simulant. This recipe required adjustment, or remediation, of the simulant purchased from Optima. Table 3-6 shows the original simulant formulation, the remediation recipe, and the combined total.

Entrained solids (0.1 w%) were added to the remediated partial supernate simulant in the Precipitate Tank at the EDL to complete the AN-102 simulant. The recipe for the EDL additions is included in Table 3-6.

Nonradioactive surrogates for the transuranic compounds were cerium nitrate, lanthanum nitrate, and neodymium nitrate. These surrogates were selected in sufficient quantity to be comparable to those selected by Nash et al. (10) for bench scale studies. This selection assumes that the lanthanides react chemically in the same manner as the actinides. The decision had been made to eliminate the technetium ion exchange from the WTP by the time Batch 3 was to be run. Therefore, sodium perrhenate was not added to the simulant.

Detailed comparison between the recipe and actual simulant formulations for both Batch 3 and 4 are shown in Appendix B.

Table 3-6. AN-102 Recipe Quantities Before Precipitating Reagents Added

AN-102R2 Simulant			Optima Recipe		Remediation Recipe		Combined					
			Chemical including water	Chemical without water	Chemical including water	Chemical without water	Chemical including water	Chemical without water			Na content	
Compounds	Formula	Formula Weight	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	Conc., mg/mL	Conc., Molar	mass, grams	Conc., Molar
Total water (excluding water of hydration)			320717.44		283241.14		603958.58					
Cadmium Nitrate	$Cd(NO_3)_2.4H_2O$	308.48	0.00	0.00	110.83	84.96	110.83	84.96	0.105	0.00034		
Calcium Nitrate	$Ca(NO_3)_2.4H_2O$	236.15	767.92	533.79	1149.42	798.97	1917.34	1332.76	1.641	0.01000		
Cerium Nitrate	$Ce(NO_3)_3.6H_2O$	434.22	0.00	0.00	91.76	68.94	91.76	68.94	0.085	0.00020		
Cesium Nitrate	$CsNO_3$	194.91	11.34	11.34	4.13	4.13	15.47	15.47	0.019	0.00010		
Cobalt Nitrate	$Co(NO_3)_3.6H_2O$	353.03	0.00	0.00	10.93	7.59	10.93	7.59	0.009	0.00003		
Copper Nitrate	$Cu(NO_3)_2.2.5H_2O$	241.60	23.62	19.22	35.23	28.67	58.85	47.89	0.059	0.00030		
Ferric Nitrate	$Fe(NO_3)_3.9H_2O$	403.99	67.21	40.26	133.24	79.81	200.45	120.07	0.148	0.00061		
Lanthanum Nitrate	$La(NO_3)_3.6H_2O$	433.01	11.26	8.45	68.31	51.27	79.57	59.73	0.074	0.00023		
Lead nitrate	$Pb(NO_3)_2$	331.20	77.15	77.15	119.57	119.57	196.72	196.72	0.242	0.00073		
Manganous Chloride	$MnCl_2.4H_2O$	197.90	16.73	10.65	53.10	33.78	69.83	44.43	0.055	0.00043		
Neodymium Nitrate	$Nd(NO_3)_2.6H_2O$	376.36	0.00	0.00	163.46	116.55	163.46	116.55	0.144	0.00039		
Nickel Nitrate	$Ni(NO_3)_2.6H_2O$	290.81	537.11	337.64	833.55	523.99	1370.66	861.63	1.061	0.00580		
Potassium Nitrate	KNO_3	101.11	1462.79	1462.79	1883.58	1883.58	3346.37	3346.37	4.121	0.04076		
Rubidium Nitrate	$RbNO_3$	147.48	0.00	0.00	9.55	9.55	9.55	9.55	0.012	0.00008		
Strontium Nitrate	$Sr(NO_3)_2$	211.63	6.63	6.63	0.00	0.00	6.63	6.63	0.008	0.00004		
Zinc Nitrate	$Zn(NO_3)_2.6H_2O$	297.47	6.69	4.26	8.44	5.38	15.13	9.64	0.012	0.00006		
Zirconyl Nitrate	$ZrO(NO_3)_2.H_2O$	249.23	11.99	11.12	12.25	11.37	24.24	22.49	0.028	0.00012		
EDTA	$Na_2C_{10}H_{14}N_2O_8.2H_2O$	372.24	1002.34	905.41	1373.63	1240.78	2375.97	2146.19	2.643	0.00786	293	0.016
HEDTA	$C_{10}H_{18}N_2O_7$	278.26	0.00	0.00	194.19	194.19	194.19	194.19	0.239	0.00100	48	
Trisodium HEDTA	$Na_3C_{10}H_{15}N_2O_7$	344.21	64.55	64.55	0.00	0.00	64.55	64.55	0.079	0.00023	13	0.001
Sodium Gluconate	$CH_2OH(CHOH)_4COONa$	218.14	280.49	280.49	810.73	810.73	1091.22	1091.22	1.344	0.00616	115	0.006
Citric Acid	$HOC(CH_2CO_2H)_2CO_2H$	192.13	180.69	180.69	3250.38	3250.38	3431.07	3431.07	4.225	0.02199		
Nitrilotriacetic Acid	$N(CH_2COOH)_3$	191.14	67.13	67.13	107.47	107.47	174.60	174.60	0.215	0.00112		
Iminodiacetic Acid	$HN(CH_2CO_2H)_2$	133.10	1189.74	1189.74	1830.68	1830.68	3020.42	3020.42	3.720	0.02795		
Succinic Acid	$C_4H_6O_4$	118.04	9.45	9.45	14.80	14.80	24.25	24.25	0.030	0.00025		
Glutaric Acid	$C_5H_8O_4$	132.12	0.00	0.00	43.82	43.82	43.82	43.82	0.054	0.00041		
Adipic Acid	$C_6H_{10}O_4$	146.14	0.00	0.00	164.93	164.93	164.93	164.93	0.203	0.00139		
Azelaic Acid	$C_9H_{16}O_4$	188.22	0.00	0.00	689.69	689.69	689.69	689.69	0.849	0.00451		
Suberic Acid	$C_8H_{14}O_4$	174.20	0.00	0.00	1213.14	1213.14	1213.14	1213.14	1.494	0.00858		
Ammonium Acetate	NH_4CH_3COO	77.08	0.00	0.00	416.09	416.09	416.09	416.09	0.512	0.00665		

AN-102R2 Simulant			Optima Recipe		Remediation Recipe		Combined					
			Chemical including water	Chemical without water	Chemical including water	Chemical without water	Chemical including water	Chemical without Hydration			Na content	
Compounds	Formula	Formula Weight	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	Conc., mg/mL	Conc., Molar	mass, grams	Conc., Molar
Boric acid	H_3BO_3	61.83	60.52	60.52	79.02	79.02	139.54	139.54	0.172	0.00278		
Sodium Chloride	$NaCl$	58.44	1653.53	1653.53	3535.58	3535.58	5189.11	5189.11	6.391	0.10935	2041	0.109
Sodium Fluoride	NaF	41.99	1283.45	1283.45	1235.85	1235.85	2519.30	2519.30	3.103	0.07389	1379	0.074
Sodium Sulfate	Na_2SO_4	142.04	5068.08	5068.08	7317.24	7317.24	12385.32	12385.32	15.253	0.10738	4009	0.215
Potassium Molybdate	K_2MoO_4	238.14	37.80	37.80	36.55	36.55	74.35	74.35	0.092	0.00038		
Sodium Hydroxide	$NaOH$	40.00	37961.38	37961.38	26654.63	26654.63	64616.01	64616.01	79.576	1.98941	37138	1.989
Aluminum Nitrate	$Al(NO_3)_3.9H_2O$	375.13	53931.28	30641.04	59274.31	33676.68	113205.59	64317.72	79.209	0.37165		
Sodium Phosphate	$Na_3PO_4.12H_2O$	380.12	5280.63	2279.96	9376.45	4048.36	14657.08	6328.32	7.793	0.04749	2659	0.142
Sodium Tungstate	$Na_2WO_4.2H_2O$	329.86	0.00	0.00	199.52	177.74	199.52	177.74	0.219	0.00074		
Sodium Metasilicate	$Na_2SiO_3.9H_2O$	284.14	0.00	0.00	67.18	28.88	67.18	28.88	0.036	0.00029		
Sodium Formate	$NaHCOO$	68.01	3119.22	3119.22	5314.92	5314.92	8434.14	8434.14	10.387	0.15273	2851	0.153
Sodium Glycolate	$HOCH_2COONa$	98.01	3708.63	3708.63	5361.59	5361.59	9070.22	9070.22	11.170	0.11397	2128	0.114
Sodium Acetate	$NaCH_3COO.3H_2O$	136.08	446.70	269.44	0.42	0.25	447.12	269.69	0.332	0.00405	76	0.004
Sodium Oxalate	$Na_2C_2O_4$	134.00	200.38	200.38	267.24	267.24	467.62	467.62	0.576	0.00430	160	0.009
Sodium Chromate	Na_2CrO_4	161.97	208.22	208.22	311.57	311.57	519.79	519.79	0.640	0.00395	148	0.008
Sodium Carbonate	Na_2CO_3	105.99	34207.58	34207.58	30115.85	30115.85	64323.43	64323.43	79.216	0.74739	27904	1.495
Sodium Nitrate	$NaNO_3$	84.99	31044.24	31044.24	40472.77	40472.77	71517.01	71517.01	88.075	1.03630	19346	1.036
Sodium Nitrite	$NaNO_2$	69.00	32780.27	32780.27	32945.07	32945.07	65725.34	65725.34	80.943	1.17308	21899	1.173
Total before dilution			537504.20	189744.50	520603.80	205384.61	1058108.00	395129.11			122208	6.544
Volume, ml							812308.00					
Calculated density, gm/ml							1.303					
Water to dilute to 6.0 M Na							67692.00					
Total after dilution							1125800.00					6.041
Volume, ml							880000.00					
Calculated density, gm/ml							1.279					

Table 3-6. AN-102 Recipe Quantities Before Precipitating Reagents Added - continued

AN-102R2 Entrained solids						
				Recipe amounts for 812 liters		
				Compound	Water	Non-water
Compounds		Formula	Formula Weight	mass, grams	mass, grams	mass, grams
Aluminum Oxide		Al_2O_3	101.96	174.3	0.00	174.30
Barium Sulfate		$BaSO_4$	233.4	0.23	0.00	0.23
Calcium Oxalate		CaC_2O_4·	146.11	1.5	0.00	1.50
Calcium Tungstate		$CaWO_4$	287.93	1.27	0.00	1.27
Cerium Oxalate		$Ce(C_2O_4$	544.29	0.23	0.00	0.23
Chromic Oxide		Cr_2O_3	151.99	10.72	0.00	10.72
Ferric Hydroxide		FeO(OH	88.85	7.84	0.00	7.84
Lanthanum Oxalate		$La_2(C_2O$	722.03	0.23	0.00	0.23
Lead Sulfate		$PbSO_4$	303.25	0.92	0.00	0.92
Manganese Dioxide		MnO_2	86.94	1.73	0.00	1.73
Neodymium Oxalate		$Nd_2(C_2O$	732.69	0.46	0.00	0.46
Nickel Oxide		NiO	74.71	0.12	0.00	0.12
Silicon Oxide		SiO_2	60.09	0.58	0.00	0.58
Sodium Carbonate		Na_2CO_3·	124.01	492.36	0.00	492.36
Sodium Fluoride		NaF	41.99	36.31	0.00	36.31
Sodium Oxalate		$Na_2C_2O_4$	134.00	185.60	0.00	185.60
Sodium Phosphate		Na_3PO_4·	380.12	141.56	0.00	141.56
Sodium Sulfate		Na_2SO_4·	322.04	96.26	0.00	96.26
Zinc Oxalate		ZnC_2O_4·	189.45	0.23	0.00	0.23
Zirconium Oxide		ZrO_2	60.09	0.23	0.00	0.23
Total solids added				1152.68	0.00	1152.68

3.6 TESTING

Complete testing details for each batch are documented in the test matrix (shown in Table 1-2), the test procedures, the laboratory logbooks, and the Data Acquisition System logs. The operating procedures and the logbooks will be retrievably archived by WSRC for inspection as needed. The DAS logs are stored in Excel format and are included on the report CD-ROM. The first page of each log is included in Appendix J to show the file name and format.

3.6.1 General test procedure

The correct amount and type of supernate simulant was loaded into the clean precipitation tank and dilution water added as required to make up the quantities shown in Table 1-2. Entrained solids were added according to the recipe. The mixer was adjusted to the appropriate level and the recirculation pump flow was adjusted to the proper rate. The tank contents were heated if necessary. A sample of the simulant was collected.

If a caustic adjustment was needed, either solid or 50% sodium hydroxide was added in the proper amount. (When 50% caustic was used the dilution water was reduced appropriately due to the water content of the caustic solution.) The temperature was brought to that specified in Table 1-2 and stabilized. A sample of the caustic adjusted simulant was collected.

The recycle flow of the previously mixed strontium nitrate was adjusted to the specified rate. At the correct time the reagent was valved to the precipitation tank and the flow rate quickly adjusted for the minor deviations due to changing the flow path. After the correct time, the reagent flow to the precipitation tank was stopped. After a sufficient wait time to ensure the strontium nitrate was fully mixed into the precipitation tank, a sample was collected.

The recycle flow of the previously mixed sodium permanganate was adjusted to the specified rate. At the correct time the reagent was valved to the precipitation tank and the flow rate quickly adjusted for the minor deviations due to changing the flow path. After the correct addition time, the reagent flow to the precipitation tank was stopped.

The tank was maintained at the specified temperature for the specified duration. Samples were collected periodically from the tank and filtered as quickly as possible. After the specified reaction time, the crossflow filter feed tank was filled. The slurry was cooled to about 25 ^{o}C and filtration was started. (An 18-hour slurry cooldown rate was imposed for Batch 4A.)

While dewatering the slurry, the crossflow filter tank was maintained between about 60 and 100 liters by transferring slurry from the precipitation tank as needed. The precipitation tank was continually mixed during filtering.

3.6.2 Specific Test Summaries

Table 3-7 through Table 3-12 provide a chronological summary of the actions during testing of each precipitation batch.

Table 3-7. Batch 1 Test Summary

Time	M/D, 2001	Action	Condition/Comment
10:36	9/25	Filled Precipitate Tank w/AN-107 simulant supernate, solids and Sodium Perrhenate	Well mixed at 50 °C and Task Plan Conditions for Batch #1
10:10	9/26	Test Conditions reestablished and first Slurry Sample (1L+1S) taken	Sample vacuum filtered and solids dried before reagent addition completed.
13:17	9/26	Started strontium nitrate addition	Addition of 11910 gms of strontium nitrate in 53370 gms of water completed at 13:25 hours
13:35	9/26	Started sodium permanganate addition	Addition of 5415 gms of sodium permanganate in 36395 gms of water completed at 13:39 hours
13:40	9/26	First vapor sample 1G completed	Sample to ADS for analysis.
13:47	9/26	Second Slurry Sample (2L+2S) taken 7.5 minutes ARA	Sample vacuum filtered and solids dried
13:50	9/26	Second vapor sample 2G completed	Sample to ADS for Analysis
13:54	9/26	Third Slurry Sample (3L+3S) taken 15 minutes ARA	Sample vacuum filtered and solids dried
14:09	9/26	Fourth Slurry Sample (4L+4S) taken 30 minutes ARA	Sample vacuum filtered and solids dried
14:32	9/26	Fifth Slurry Sample (5L+5S) taken 1 hour ARA	Sample vacuum filtered and solids dried
14:34	9/26	Third vapor sample 3G completed	Sample to ADS for Analysis
15:34	9/26	Sixth Slurry Sample (6L+6S) taken 2 hours ARA	Sample vacuum filtered and solids dried
16:32	9/26	Seventh Slurry Sample (7L+7S) taken 3 hours ARA	Sample vacuum filtered and solids dried
16:37	9/26	Fourth vapor sample 4G completed	Sample to ADS for Analysis
17:35	9/26	Eighth Slurry Sample (8L+8S) taken 4 hours ARA	Sample vacuum filtered and solids dried
17:48	9/26	Stopped Temperature Controller	Precipitate Tank starts cooling naturally at about 1.5 °C per hour
18:00	9/26	Feed from Precipitate Tank to Slurry Reservoir commences	Precipitated slurry cooled to 25 °C using chilled water through cooling coils in Slurry Reservoir
18:29	9/26	Began filtering slurry at various velocities and TMPs	Initial Backpulse performed
19:40	9/26	Ninth Slurry Sample (9L+9S) taken from crossflow slurry loop 6 hours ARA	Sample vacuum filtered and solids dried
21:08	9/26	Two one liter filtrate samples (PF1-1 & PF1-2) taken for Lasentec analysis.	7.5 hours reaction time after reagent addition completed
21:35	9/26	Tenth Slurry Sample (10L+10S) taken from crossflow slurry loop 480 minutes after reagent addition completed.	Sample vacuum filtered and solids dried.
10:13	9/28	Established filtrate production of 0.05 gpm per ft^2 of filter inside surface area.	V=16.3 ft/sec, TMP=42.2 psi
12:53	9/28	Took third filtrate sample (PF1-3) for Lasentec.	47.2 hours reaction time after reagent addition completed
15:43	10/1	Took fourth filtrate sample (PF1-4) for Lasentec.	122 hours reaction time after reagent addition completed
15:08	10/2	Took fifth filtrate sample (PF1-5) for Lasentec.	145 hours reaction time after reagent addition completed
14:00	11/13	Completed pulling a 100 ml ADS Sample 3-172181 from AN-107 Slurry Drum Batch #1	Sample submitted to ADS for Microtrac Analysis of slurry solids
11:30	11/20	Collected several liters of the Batch #1 Filtrate from the drum in storage for ADS Sample 172483 solids analysis	The samples collected were vacuum filtered and dried to produce approximately one gram of solids for XRD, ICPMS and ICP-ES analysis.

Table 3-8. Batch 2 Test Summary

Time	M/D, 2001 UOS	Action	Condition/Comment
12:45	10/11	Filled Precipitate Tank w/AN-107 simulant supernate, solids and Sodium Perrhenate	Well mixed at 20 ^oC and Task Plan Conditions for Batch #2
08:54	10/23	Started caustic addition of 34 liters at 19 M NaOH to raise NaOH concentration by 1M.	Test Conditions for one hour before caustic addition include Recirculation Pump flow 9.64 gpm, Agitator 327.6 rpm, TCs 20 ^oC.
09:15	10/23	Caustic adjustment completed and first Slurry Sample (1L+1S) taken	Sample vacuum filtered and solids before reagent addition completed.
09:25	10/23	Started strontium nitrate addition	Addition of 11910 grs strontium nitrate in 53365 gms of water completed at 09:32
09:43	10/23	Started sodium permanganate addition	Addition of 5389 gms of sodium permanganate in 37271 gms of water completed at 09:47
09:47	10/23	First vapor sample 1G completed	Sample to ADS for analysis.
09:54	10/23	7.5 minute ARA Slurry Sample (2L+2S) collected	Sample vacuum filtered and solids dried
09:57	10/23	Second vapor sample 2G completed	Sample to ADS for Analysis
10:03	10/23	15 minute ARA Slurry Sample (3L+3S) collected	Sample vacuum filtered and solids dried
10:18	10/23	30 minute ARA Slurry Sample (4L+4S) collected	Sample vacuum filtered and solids dried
10:48	10/23	1 hour ARA Slurry Sample (5L+5S) collected	Sample vacuum filtered and solids dried
11:00	10/23	Third vapor sample 3G completed	Sample to ADS for Analysis
11:47	10/23	2 hour ARA Slurry Sample (6L+6S) collected	Sample vacuum filtered and solids dried
12:45	10/23	3 hour ARA Slurry Sample (7L+7S) collected	Sample vacuum filtered and solids dried
12:55	10/23	Fourth vapor sample 4G completed	Sample to ADS for Analysis
13:00	10/23	First filtrate sample (PF2-1) taken for Lasentec.	3.2 hours ARA
13:44	10/23	4 hour ARA Slurry Sample (8L+8S) collected	Sample vacuum filtered and solids dried
14:44	10/23	Filled Crossflow Filter Slurry Reservoir and started filtering	V=10.25 ft/sec, TMP=48.74 psid
15:44	10/23	6 hour ARA Slurry Sample (9L+9S) collected	Sample vacuum filtered and solids dried
17:44	10/23	8 hour Slurry Sample (10L+10S) collected	Sample vacuum filtered and solids dried.
00:15	10/24	Took second filtrate sample (PF2-2) for Lasentec.	14.5 hours ARA
07:30	10/24	Took third filtrate sample (PF2-3) for Lasentec.	21.7 hours ARA
16:00	10/24	Took fourth filtrate sample (PF2-4) for Lasentec.	30.2 hours ARA
00:05	10/25	Took fifth filtrate sample (PF2-5) for Lasentec.	38.3 hours ARA
07:30	10/25	Took sixth filtrate sample (PF2-6) for Lasentec.	45.7 hours ARA
14:00	11/13	Completed pulling a 100 ml ADS Sample 172182 from AN-107 Slurry Drum Batch #2	Sample submitted to ADS for Microtrac Analysis of slurry solids
11:30	11/20	Completed pulling several liters of Coliwasa samples from the Batch #2 Filtrate in drums #2 and #3 in storage for ADS Sample 172484 solids analysis	The samples collected were vacuum filtered and dried to produce approximately one gram of solids for XRD, ICP-MS and ICP-ES analysis.
11:00	01/22 2002	Completed pulling a one liter liquid sample from AN-107 Batch #2 Filtrate Drum for Analysis by the Mobile Lab	ICP-ES elemental analysis performed for comparison with ADS 170454

Table 3-9. Batch 3C Test Summary

Time	M/D, 2002	Batch 3C Action	Condition/Comment
10:30	9/30	Filled Precipitate Tank w/AN-102R2 simulant supernate, entrained solids and 68 liters of DIF water.	Initial and one week aged simulant samples were pulled for Batch 3C.
10:52	10/1	Confirmed test conditions established for thirty minutes.	Test Conditions before reagent addition include Recirculation Pump flow 9.64 gpm, Agitator 508 rpm, TCs 25$\pm$2 ^{o}C.
11:00	10/1	Started strontium nitrate addition	Addition complete at 11:18
11:33	10/1	Slurry Sample taken	Sample vacuum filtered and solids dried
11:48	10/1	Started sodium permanganate addition	Addition complete at 12:05
12:03	10/1	Vapor sample 1GC and 2VOA completed	Sample to ADS for analysis.
12:14	10/1	7.5 min ARA Slurry Sample collected	Sample vacuum filtered and solids dried
12:25	10/1	15 minute ARA Slurry Sample collected	Sample vacuum filtered and solids dried
12:39	10/1	30-minute ARA Slurry Sample collected	Sample vacuum filtered and solids dried
13:09	10/1	1 hr ARA Slurry Sample collected	Sample vacuum filtered and solids dried
14:08	10/1	2 hr ARA Slurry Sample collected	Sample vacuum filtered and solids dried
15:08	10/1	3 hr ARA Slurry Sample collected	Sample vacuum filtered and solids dried
16:15	10/1	4 hr ARA Slurry Sample collected	Sample vacuum filtered and solids dried
16:30	10/1	Filled Crossflow Filter Slurry Reservoir and started filtering	Feed and Bleed established to maintain Slurry Reservoir
17:00	10/1	4 hr ARA crossflow filtrate sample collected	Lasentec analysis showed no significant solids
00:05	10/2	12 hr ARA crossflow filtrate sample collected	For Lasentec determination of solids
00:55	10/2	12 hr ARA Composite Filtrate Tank sample collected	For Lasentec determination of solids
06:15	10/2	Completed filling Auxiliary Feed Tank from Precipitate Tank	Lag storage for Slurry Reservoir while Batch 3B formulated
08:25	10/2	Completed Batch 3C transfer from the Precipitate Tank	Stopped logging precipitation data
09:00	10/2	21 hr ARA crossflow filtrate sample collected	Lasentec analysis showed no significant solids
09:23	10/2	21 hr ARA Composite Filtrate Tank sample collected	Lasentec analysis showed very few solids
11:48	10/2	24 hr ARA Composite Filtrate Tank sample collected	For Lasentec determination of solids
13:08	10/3	50 hr ARA Concentrated slurry sample collected	For Microtrac ADS 3-18695 at RPP request
13:50	10/3	50 hr ARA Composite Filtrate Tank sample collected	Submitted to mobile lab for analysis
11:10	10/4	73 hr ARA Composite Filtrate Tank sample collected after vigorous agitation	Lasentec analysis showed no significant solids
07:30	10/7	105 hr ARA Composite Filtrate Tank sample collected	Submitted to mobile lab for analysis
06:45	10/8	128 hr ARA Composite Filtrate Tank sample collected	Submitted to mobile lab for analysis
06:45	10/9	152 hr ARA Composite Filtrate Tank sample collected	Submitted to mobile lab for analysis
12:00	10/9	159 hr ARA Composite Filtrate Tank sample collected	Lasentec analysis showed few solids
15:00	10/9	162 hr ARA Composite Filtrate Tank sample collected	Filtered sample, submitted filtrate to mobile lab
11:00	10/10	Turbidity Sample taken from Composite Filtrate Tank for comparison with samples stored exposed to light.	Dark stored sample Turbidity=0.159 Light stored sample Turbidity=0.279
15:23	10/10	186 hr ARA Composite Filtrate Tank sample collected	Filtered sample, submitted filtrate to mobile lab
14:20	10/11	208 hr ARA Composite Filtrate Tank sample collected	Filtered sample, submitted filtrate to mobile lab
06:30	10/14	272 hr ARA Composite Filtrate Tank sample collected	Lasentec analysis showed few solids

Table 3-10. Batch 3B Test Summary

Time	M/D, 2002	Batch 3B Action	Condition/Comment
14:10	10/21	Filled Precipitate Tank w/AN-102R2 simulant supernate, entrained solids and 68 liters of DIF water.	Initial and one week aged simulant samples were pulled for Batch 3B. 5 liters to CUF
07:00	10/22	Completed addition of 32.2 kg of NaOH with chiller on and sample taken	Sample vacuum filtered slowly due to reverse solubility SrCO3 and solids dried
08:04	10/22	Test conditions established for thirty minutes.	Test Conditions before reagent addition include Recirculation Pump flow 9.64 gpm, Agitator 508 rpm, TCs 50 ± 2 ^oC.
09:00	10/22	Started strontium nitrate addition	Addition complete at 09:43
09:58	10/22	Slurry Sample taken	Sample vacuum filtered and solids dried
10:13	10/22	Started sodium permanganate addition	Addition complete at 10:41
10:43	10/22	Vapor sample 1GC and 2VOA completed	Sample to ADS for analysis.
10:49	10/22	7.5 minute ARA Slurry Sample collected	Sample vacuum filtered and solids dried
10:57	10/22	15 minute ARA Slurry Sample collected	Sample vacuum filtered and solids dried
11:12	10/22	Slurry Sample taken at 30 minutes ARA	Sample vacuum filtered and solids dried
11:45	10/22	Slurry Sample taken at 60 minutes ARA	Sample vacuum filtered and solids dried
12:44	10/22	Slurry Sample taken at 120 minutes ARA	Sample vacuum filtered and solids dried
13:44	10/22	Slurry Sample taken at 180 minutes ARA	Sample vacuum filtered and solids dried
14:48	10/22	Slurry Sample taken at 240 minutes ARA	Sample vacuum filtered and solids dried
14:49	10/22	Valved in chiller to cool slurry	Cooling slurry from 50 ± 2 ^oC to 25 ± 2 ^oC.
15:02	10/22	Filled Crossflow Filter Slurry Reservoir and started filtering	Feed and Bleed established to maintain Slurry Reservoir
16:35	10/22	Initial Lasentec Sample taken from filtrate line on Cross-flow Test Rig	5 hours reaction time ARA
17:00	10/22	Precipitate Tank Agitator speed reduced to 327 rpm.	% load compares with Batch 1 and 2 Agitator
17:55	10/22	Started loading Auxiliary Feed Tank with 300 liters	Auxiliary feed to slurry reservoir Precip Batch 3A as lag storage
18:35	10/22	Loaded carboys with 40 liters of slurry for CUF	CUF filter operation support.
19:15	10/22	All tanks empty of Batch 3B slurry	Precip Tank filled for Batch 3A
14:06	10/23	Sample taken from Composite Filtrate Tank	Sample to Mobile Lab
15:23	10/23	Lasentec Sample taken from Composite Filtrate Tank	25 hours reaction time ARA
06:19	10/24	Sample taken from Composite Filtrate Tank	Sample to Mobile Lab
13:50	10/25	Sample taken from Composite Filtrate Tank	Sample to Mobile Lab
11:00	10/26	Sample taken from Composite Filtrate Tank	Sample to Mobile Lab
12:10	10/27	Sample taken from Composite Filtrate Tank	Sample to Mobile Lab
07:00	10/28	Sample taken from Composite Filtrate Tank	Sample to Mobile Lab
06:40	10/29	Sample taken from Composite Filtrate Tank	Sample to Mobile Lab
08:00	10/29	Lasentec Sample taken from Composite Filtrate Tank	167 hours reaction time ARA
15:25	11/4	Three 20 ml samples of solids from Filtrate Composite Tank	Sample to Mobile Lab
10:33	11/5	Post-filtration sample of solids from Filtrate Composite Tank	Sample to ADS for XRD

Table 3-11. Batch 3A Test Summary

Time	M/D, 2002	Batch 3A Action	Condition/Comment
13:14	10/23	Filled Precipitate Tank w/AN-102R2 simulant supernate, entrained solids and 62.7 liters of DIF water.	Initial and one week aged simulant samples were pulled for Batch 3A.
14:30	10/23	Completed addition of 26.1 kg of NaOH with chiller on and sample taken	Sample vacuum filtered and solids dried
16:42	10/23	Confirmed test conditions matching Batch 3B established for thirty minutes.	Test Conditions before reagent addition include Recirculation Pump flow 9.64 gpm, Agitator 507 rpm, TCs 50±2 ^oC.
18:00	10/23	Stopped Temperature Controller, pump and Agitator	Tank contents allowed to cool
08:15	10/24	Batch 3A reheating to 50±2 ^oC started	Reestablish test conditions
09:50	10/24	Test conditions matching Batch 3B established	Test Conditions before reagent addition include Recirculation Pump flow 9.64 gpm, Agitator 507 rpm, TCs 50±2 ^oC.
10:40	10/24	Stopped Temperature Controller, pump and Agitator	Tank contents allowed to cool
13:45	11/5	Obtained 5 gallon container for hourly filtrate samples	Proportional samples based on filtrate flow
06:30	11/6	Establishing new test conditions at customer direction (identical to 3B except for lower temperature)	Test Conditions before reagent addition include Recirculation Pump flow 9.64 gpm, Agitator 507 rpm, TCs 25±2 ^oC.
08:00	11/6	Confirmed test conditions established for thirty minutes.	Test Conditions before reagent addition include Recirculation Pump flow 9.64 gpm, Agitator 507 rpm, TCs 25±2 ^oC.
09:00	11/6	Started strontium nitrate addition	Addition complete at 09:40
09:45	11/6	Slurry Sample taken	Sample vacuum filtered and solids dried
10:10	11/6	Started sodium permanganate addition	Addition complete at 10:39
10:46	11/6	Slurry Sample taken at 7.5 minutes ARA	Sample vacuum filtered and solids dried
10:53	11/6	Slurry Sample taken at 15 minutes ARA	Sample vacuum filtered and solids dried
11:08	11/6	Vapor sample 1GC and 2VOA completed	Sample to ADS for analysis.
11:08	11/6	Slurry Sample taken at 30 minutes ARA	Sample vacuum filtered and solids dried
11:39	11/6	Slurry Sample taken at 60 minutes ARA	Sample vacuum filtered and solids dried
12:39	11/6	Slurry Sample taken at 120 minutes ARA	Sample vacuum filtered and solids dried
13:39	11/6	Slurry Sample taken at 180 minutes ARA	Sample vacuum filtered and solids dried
14:39	11/6	Slurry Sample taken at 240 minutes ARA	Sample vacuum filtered and solids dried
14:41	11/6	Fill of Crossflow Filter Slurry Reservoir commenced and started filtering	Feed and Bleed established to maintain Slurry Reservoir
16:20	11/6	631 ml sample taken for Composite Filtrate Tank	Put into 5 gallon container storage
16:20	11/6	Initial Lasentec Sample taken from filtrate line on Cross-flow Test Rig	6 hours reaction time after reagent addition completed
17:23	11/6	1167 ml sample taken for Composite Filtrate Tank	Added to 5 gallon container storage
18:11	11/6	1003 ml sample taken for Composite Filtrate Tank	Added to 5 gallon container storage
19:11	11/6	857 ml sample taken for Composite Filtrate Tank	Added to 5 gallon container storage
20:11	11/6	730 ml sample taken for Composite Filtrate Tank	Added to 5 gallon container storage
20:11	11/6	Lasentec Sample taken from filtrate line on Cross-flow Test Rig	10 hours reaction time after reagent addition completed
21:11	11/6	601 ml sample taken for Composite Filtrate Tank	Added to 5 gallon container storage
22:11	11/6	565 ml sample taken for Composite Filtrate Tank	Added to 5 gallon container storage
23:11	11/6	529 ml sample taken for Composite Filtrate Tank	Added to 5 gallon container storage
24:11	11/6	456 ml sample taken for Composite Filtrate Tank	Added to 5 gallon container storage
24:11	11/6	Lasentec Sample taken from crossflow filtrate line	14 hours reaction time ARA
06:11	11/7	2400 ml sample taken for Composite Filtrate Tank	Added to 5 gallon container storage
06:11	11/7	Lasentec Sample taken from crossflow filtrate line	20 hours reaction time ARA
07:11	11/7	347 ml sample taken for Composite Filtrate Tank	Added to 5 gallon container storage
08:11	11/7	328 ml sample taken for Composite Filtrate Tank	Added to 5 gallon container storage
09:11	11/7	347 ml sample taken for Composite Filtrate Tank	Added to 5 gallon container storage

Table 3-11. Batch 3A Test Summary - continued

Time	M/D, 2002	Batch 3A Action	Condition/Comment
10:11	11/7	383 ml sample taken for Composite Filtrate Tank	Added to 5 gallon container storage
10:11	11/7	Lasentec Sample taken from crossflow filtrate line	24 hours reaction time ARA
11:11	11/7	383 ml sample taken for Composite Filtrate Tank	Added to 5 gallon container storage
12:11	11/7	364 ml sample taken for Composite Filtrate Tank	Added to 5 gallon container storage
13:11	11/7	347 ml sample taken for Composite Filtrate Tank	Added to 5 gallon container storage
14:11	11/7	310 ml sample taken for Composite Filtrate Tank	Added to 5 gallon container storage
14:11	11/7	Lasentec Sample taken from crossflow filtrate line	28 hours reaction time ARA
15:11	11/7	292 ml sample taken for Composite Filtrate Tank	Added to 5 gallon container storage
16:11	11/7	292 ml sample taken for Composite Filtrate Tank	Added to 5 gallon container storage
17:00	11/7	292 ml sample taken for Composite Filtrate Tank	Added to 5 gallon container storage
10:25	11/13	Lasentec Sample taken from 5 gallon composite filtrate storage container	168 hours reaction time ARA
08:16	11/20	Lasentec Sample taken from 5 gallon composite filtrate storage container	335 hours reaction time ARA

Table 3-12. Batch 4A Test Summary

Time	M/D, 2003	Batch 4A Action	Condition/Comment
15:43	3/10	Filled Precipitate Tank w/AN-102R2 simulant supernate, entrained solids and 14 liters of DIF water.	Initial and one week aged simulant samples were pulled for Batch 4A. Press Regulator at 16.5 psig, Pressure Stop at 22.00 inches, Pulse Tube Pressure Time is 1.49 sec
07:03	3/11	Confirmed test conditions established for thirty minutes.	Test Conditions before reagent addition include Pulse Tube pressure time 1.46 sec, Pressure Regulator at 17 psig, Recirc flow 0.5 gpm and Tank Bottom TC 50$\pm$2 ^{o}C.
07:11	3/11	Completed addition of 23 liters of 50 wt% NaOH with heater on	Pulse Tube Pressure Time is 1.51 sec with Pressure stop set at 22.4 inches
07:31	3/11	Reagent Tank Recirc pumps started	Flow adjusted to 0.45 gpm
07:53	3/11	Vapor sampling syringe attached to V64	Preparation for vapor sampling complete
08:11	3/11	Caustic addition sample removed from V53	Sample stabilized
08:15	3/11	Started strontium nitrate addition	Addition complete at 08:47
08:57	3/11	Pressure Stop Set changed to 23.4 inches	Pulse Tube Pressure Time is 1.63 sec
09:04	3/11	Slurry Sample taken	Sample stabilized
09:16	3/11	Pressure Stop Set changed to 24.4 inches	Pulse Tube Pressure Time is 1.63 sec
09:17	3/11	Started sodium permanganate addition	Addition complete at 09:38
09:23	3/11	Pressure Stop Set changed to 24.9 inches	Pulse Tube Pressure Time is 1.63 sec
09:30	3/11	Pressure Stop Set changed to 25.4 inches	Pulse Tube Pressure Time is 1.63 sec
09:33	3/11	Pressure Stop Set changed to 26.4 inches	Pulse Tube Pressure Time is 1.63 sec
09:35	3/11	Pressure Stop Set changed to 26.5 inches	Pulse Tube Pressure Time is 1.63 sec
09:40	3/11	Vapor sample 1GC and 2VOA completed	Sample to ADS for analysis.
09:49	3/11	Stopped heater due to exothermic precip reaction	Bottom Tank Temp 54.42 ^{o}C
09:50	3/11	Slurry Sample taken at 7.5 minutes ARA	Sample stabilized
09:57	3/11	Slurry Sample taken at 15 minutes ARA	Sample stabilized
10:01	3/11	Pressure Stop Set changed to 27 inches	Pulse Tube Pressure Time is 1.62 sec
10:12	3/11	Slurry Sample taken at 30 minutes ARA	Sample stabilized
10:18	3/11	Recorded observations during sodium permanganate addition about 09:17	Recycle from bottom of tank yellow (strontium carbonate solids) until about 20 seconds after the first pulse. It then quickly changed to an orange color. Meanwhile, the purple sodium permanganate spread rapidly across the top of the tank, initially changing to a dark green around the edges. About 20 seconds after the second pulse, the recycle stream darkened abruptly. After each pulse, the recycle stream darkened until at the fifth and sixth pulse, the color was a steady brown.
10:30	3/11	Pressure Stop and Vacuum Stop at 27 inches	Pulse Tube Pressure Time is 1.64 sec
10:40	3/11	Slurry Sample taken at 1 hour ARA	Sample stabilized
10:44	3/11	Started Temperature Controller	Tank Bottom TC 50$\pm$2 ^{o}C.
11:39	3/11	Slurry Sample taken at 2 hours ARA	Sample Stabilized
12:26	3/11	Connected V55 valve to discharge line	Preparation for Slurry Reservoir transfer
12:39	3/11	Slurry Sample taken at 3 hours ARA	Sample stabilized
13:33	3/11	Temperature Controller off	Tank Bottom TC 50$\pm$2 ^{o}C.
13:39	3/11	Slurry Sample taken at 4 hours ARA	Sample stabilized. Commencing 18 hour cool down.
15:03	3/11	Observed Pulse Tube Pressure Time increase to 1.71 sec as PJM Tank contents cooled.	Tank Bottom temperature at 49 ^{o}C. Pressure Regulator reset to 18 psig and Press Stop reset to 27.5 inches. Pulse Tube Pressure Time is 1.62 sec

Table 3-12. Batch 4A Test Summary - continued

Time	M/D, 2003	Batch 4A Action	Condition/Comment
17:24	3/11	Fan installed	Cool down accelerated
19:08	3/11	Pressure Stop Set changed to 26.6 inches	Pulse Tube Pressure Time is 1.6 sec
22:28	3/11	Recirc Pump leak observed	Recirc flow secured. Pump flow had been restricted by bent metal ball seal and not slurry accumulation. Estimated maximum leakage of 4.5 liters slurry.
24:00	3/11	Recirc Pump replaced	Tank Bottom temperature at 36.7 ^{o}C.
01:34	3/12	Pressure Stop Set changed to 25.6 inches	Pulse Tube Pressure Time is 1.6 sec. Tank Bottom temperature at 35.1 ^{o}C.
02:52	3/12	Control Program stopped reading data.	PJM Tank blow out during program restart. Pressure Stop Set changed to 26.6 inches
03:01	3/12	Pressure Stop Set changed to 26 inches	Tank Bottom temperature at 32.98 ^{o}C. Fan speed increased to maximum. Pulse Tube Pressure Time is 1.58 sec.
03:17	3/12	Pressure Stop Set changed to 25.7 inches	Tank Bottom temperature at 32.6 ^{o}C. Pulse Tube Pressure Time is 1.58 sec.
03:27	3/12	Pressure Stop Set changed to 25.6 inches	Pulse Tube Pressure Time is 1.62 sec.
04:16	3/12	Pressure Stop Set changed to 25.4 inches	Tank Bottom temperature at 31.24 ^{o}C. Pulse Tube Pressure Time is 1.6 sec.
04:24	3/12	Pressure Stop Set changed to 25.3 inches	Pulse Tube Pressure Time is 1.63 sec.
06:46	3/12	Pressure Stop Set changed to 25.0 inches	Pulse Tube Pressure Time is 1.6 sec.
07:28	3/12	Slurry Sample number 11 pulled	Sample stabilized. Tank Bottom temperature at 27.9^{o}C. Commenced transfer to Surry Reservoir in Cross flow Test Rig.
07:37	3/12	Pressure Regulator setting reduced to 15 psig. Pressure Stop Set changed to 22.0 inches	Pulse Tube Pressure Time is 1.59 sec.
07:44	3/12	Pressure Stop Set changed to 21.8 inches	Pulse Tube Pressure Time is 1.56 sec.
07:46	3/12	Pressure Stop Set changed to 21.6 inches	Pulse Tube Pressure Time is 1.60 sec.
07:54	3/12	Pressure Stop Set changed to 19.6 inches and Vacuum Stop Set changed to 26.0 inches	Pulse Tube Pressure Time is 1.65 sec.
07:58	3/12	Vacuum Stop Set changed to 24.0 inches	Pulse Tube Pressure Time is 1.55 sec.
08:06	3/12	Pressure Stop Set changed to 18.6 inches and Vacuum Stop Set changed to 20.0 inches	Pressure Regulator reduced to 12 psig. Pulse Tube Pressure Time is 1.66 sec.
08:14	3/12	Vacuum Blower off. Pressure Stop Set changed to 19.6 inches	Pressure Regulator reduced to 9 psig. Pulse Tube Pressure Time is 1.71 sec.
08:15	3/12	Pressure Stop Set changed to 20.6 inches	Pulse Tube Pressure Time is 1.54 sec.
08:18	3/12	Pressure Stop Set changed to 19.6 inches	Pulse Tube Pressure Time is 1.71 sec.
09:11	3/12	Pressure Regulator reduced to 8 psig. Pressure Stop Set changed to 19.0 inches	Pulse Tube Pressure Time is 1.71 sec. Tank level by tape is 23.8 inches versus level probe indicating 22.2 inches.
09:12	3/12	Pressure Stop Set changed to 20.0 inches	Pulse Tube Pressure Time is 1.46 sec.
09:13	3/12	Pressure Stop Set changed to 19.5 inches	Pulse Tube Pressure Time is 1.58 sec.
10:11	3/12	Pressure Stop Set changed to 15.5 inches	Pulse Tube Pressure Time is 2.05 sec. Tank level by tape is 21.75 inches versus level probe indicating 20.4 inches.
10:13	3/12	Pressure Stop Set changed to 18.5 inches	Pulse Tube Pressure Time is 1.46 sec. Blow out
10:14	3/12	Pressure Regulator reduced to 8.5 psig. Pressure Stop Set changed to 19.5 inches	Pulse Tube Pressure Time is 1.06 sec.

Table 3-12. Batch 4A Test Summary - continued

Time	M/D, 2003	Batch 4A Action	Condition/Comment
10:16	3/12	Pressure Stop Set changed to 18.5 inches	Pulse Tube Pressure Time is 1.41 sec.
10:18	3/12	Pressure Stop Set changed to 18.0 inches	Pulse Tube Pressure Time is 1.29 sec.
11:00	3/12	Pressure Stop Set changed to 17.9 inches	Pulse Tube Pressure Time is 1.26 sec.
11:01	3/12	Pressure Stop Set changed to 17.8 inches	Pulse Tube Pressure Time is 1.30 sec.
11:03	3/12	Pressure Stop Set changed to 17.8 inches	Pulse Tube Pressure Time is 1.32 sec.
11:04	3/12	Pressure Stop Set changed to 17.0 inches	Pulse Tube Pressure Time is 1.30 sec.
11:06	3/12	Pressure Stop Set changed to 16.5 inches	Pulse Tube Pressure Time is 1.58 sec.
11:07	3/12	Pressure Stop Set changed to 16.4 inches	Pulse Tube Pressure Time is 1.55 sec.
11:10	3/12	Pressure Stop Set changed to 16.2 inches	Pulse Tube Pressure Time is 1.74 sec.
11:12	3/12	Pressure Stop Set changed to 16.3 inches	Pulse Tube Pressure Time is 1.72 sec.
12:07	3/12	Pressure Stop Set changed to 15.85 inches	Pulse Tube Pressure Time is 1.26 sec.
13:02	3/12	Pressure Stop Set changed to 15.95 inches	Pulse Tube Pressure Time is 1.07 sec.
13:36	3/12	Pressure Stop Set changed to 15.85 inches	Pulse Tube Pressure Time is 0.68 sec.
13:43	3/12	Stopped pulse and vented tube	Tank Level 14.26 inches per probe. Recirc flow reduced to 0.84 gpm to reduce foaming.
00:14	3/13	Stopped recirc Pump	Unable to maintain recirc flow as too little slurry remaining.
01:30	3/13	Disconnected transfer line from V55 and capped end. Opened drain and pumped 3 liters out of PJM Tank for final feed to Slurry Reservoir.	Used JABSCO pump to suck out foam from PJM Tank for feed to Slurry Reservoir. Filled Post Filtration Tank with agitator running.

3.7 SAMPLE HANDLING CONCERNS

3.7.1 Deadend Filtration Times

Collecting representative samples from tanks containing slurries is always problematical. One-liter samples were collected from the precipitation tank. Although these were very large in comparison to the amount needed for analysis, they were small in comparison to the contents of the tank. In an attempt to collect a representative sample, the sample lines were continually flushed back to the tank through three-way valves, so they would continually contain fresh sample. As described in the equipment section of this report, an isokinetic sample takeoff was provided. Since the pump recycle line was a 1½-inch pipe, the ½-inch OD sample tube was actually small in comparison, but still large in terms of sample flow rate. The greatest variation in sample contents will occur when the sample line is opened and closed, because the velocities will not be matched until full flow is established. The one-liter samples were intended to help minimize the chance of unintentional separation of solids from the liquid during these flow transitions.

Experience was gained as experimentation progressed leading to improved sample handling and pretreatment prior to analysis. For Batch 1, the one-liter samples were collected and filtered through 0.2 micron filter papers placed into 0.2 micron filter cups. The use of filter paper was intended to allow more accurate weight determinations since the solids could be easily removed on the filter paper for drying. However, it turned out that the deadend filtration was much slower than anticipated, in some cases taking many hours to complete. A sample collected 7.5 minutes after reagent addition, but requiring hours to filter, can certainly not be considered to provide the snapshot of precipitating reaction kinetic conditions that was desired.

For Batch 2, the filter paper was eliminated and the entire filter cup was placed in the oven for drying. This speeded up the filtration, but a sample could still take a few hours to filter completely.

For Batch 3 experiments, a much bigger vacuum line was used to attach the filter cups to the pump. This speeded up the filtration so most of them could be completed in about 30 minutes. The sample collected after addition of the strontium nitrate was a notable exception. It still took many hours to filter that sample.

An additional complication was that samples collected from heated precipitation batches cooled down as filtration took place. This was especially significant for the slowly filtering sample collected after strontium nitrate addition. Strontium carbonate has a strong solubility dependence on temperature. This dependence is opposite that of most salts, with the solubility being higher in cool solutions. As hot samples were being filtered, the solids content in the liquid above the filter changed visually from as much as 50% of the volume to less than 5% as the solution cooled. Clearly, the initial filtrate that passes through the filter will have a significantly lower amount of strontium carbonate than the filtrate that is collected after the sample has cooled.

For Batch 4, a one-liter sample was still collected, but only the first 200 ml of filtrate was collected and submitted for analysis.

3.7.2 Sample Stability

It became apparent as experimentation progressed that the samples were not stable. Archived samples of filtrate formed precipitants that settled to the bottom, and crystals that adhered to the sides of the bottle. These changes occurred even in samples placed in cardboard boxes to shield them from light. The light was considered a catalyst for further precipitation with the permanganate over time.

Variations in the length of time between collection and analysis could result in significant variations in the analysis. When this instability became apparent after the Batch 2 experiment, attempts were made to minimize the time delay before analysis. This was not always possible. During the analysis of the Batch 3B samples, the ICP-ES machine broke down. The 3 and 4 hour ARA filtrate samples could not be run for a few days after the other samples. Comparison of the analytical results clearly shows that this delay had a marked effect. Likewise, the archived samples could not be used to improve the analysis since they had the same instability problem.

For Batch 4 the filtrate samples were immediately diluted and acidified in preparation for the ICP-ES machine before being submitted to the analytical groups. Arrangements were made to analyze slurry samples immediately after collection, even if it required someone to be held over on overtime.

In general, the analysis of samples from the later experiments can be considered to be more reliable than the earlier experiments. Most importantly, the Batch 4 samples taken from the most critical pulse jet mixed precipitation were all either acid-stabilized prior to submittal, or run immediately by the analytical group.

3.8 TYPICAL CALCULATIONS

For Batch 1, the solids filtered out of one-liter samples increased from 4.0 grams before precipitation to 41.4 grams after precipitation. Based on a filtrate density of 1.24, the solids content was 41.4 / (1240 + 41.4) * 100% = 3.2 wt%. For Batch 2 the solids filtered out of one-liter samples increased from 4.0 grams before precipitation to 45 grams after precipitation, for a calculated solids content of 3.5 wt%. Note that these solids included soluble salts left behind when the damp filtrate was dried.

For Batches 3 & 4 the solids analysis was done by the analytical group. A portion of the slurry sample was dried to determine the total solid content. The remaining slurry was filtered and the filtrate dried to determine the soluble solid content. These two values were then used to calculate the insoluble solid content.

The concentrations of elements in the treated liquid as a function of time after reagent addition were determined by collecting and analyzing samples as shown in Appendix C through Appendix H. In order to make an accurate comparison, the concentrations after reagent additions need to be corrected for the effect of dilution by the reagents. To make this correction, all concentrations after reagents were added must be multiplied by the appropriate mass dilution factor MD defined in Equation 1:

Equation 1

$$MD = \frac{(\text{mass of simulant} + \text{mass of all additions})}{(\text{mass of simulant})}$$

Using Batch 2 for example, after the caustic addition the mass dilution factor was

MD = (795691 grams simulant + 51860 grams caustic) / (795691 grams simulant) = 1.07.

After all reagents were added the mass dilution factor was

MD = (795691 grams + 51860 grams caustic + 65275 grams strontium nitrate solution + 42660 grams sodium permanganate solution) / (795691 grams simulant) = 1.20.

A substantial step change occurs in strontium concentration when the reagents are added. There were 11910 grams of strontium nitrate containing 4931 grams of strontium added to the simulant in Batch 2. By calculation, the dilution-corrected concentration of strontium would approach (4931) / (795691) = 6200 μg/gm if it remained in solution. Similarly, there were 5389 grams of sodium permanganate containing 2086 grams of manganese added. By calculation, the dilution-corrected concentration of manganese would approach (2086) / (795691) = 2622 μg/gm. However, since the precipitation reactions are very rapid, these very high concentrations were not captured by any of the samples.

As a common measure of the removal efficiency for an element, the initial mass of the element in the feed is divided by the mass remaining in the treated liquid. This measure is called the decontamination factor (DF).

$$\text{DF Element “A”} = \frac{\text{(mass of element “A” in simulant)}}{\text{(mass of element “A” in treated liquid)}}$$

$$\text{DF Element “A”} = \frac{\text{(mass concentration of element “A” in simulant)}}{\text{(mass concentration of element “A” in treated liquid)(MD)}}$$

Again, use Batch 2 for example. The ADS-measured cerium concentration in the simulant before precipitation was 26.4 μg/gm. Four hours after all the precipitating reagents were added, the concentration dropped to 2.33 μg/gm.

The 4-hour DF_{Ce} = (26.4) / ((2.33)(1.20)) = 9.4.

An alternate measure of the decontamination is the percent removed calculated as follows:

$$\text{\% Removed} = \frac{\text{(mass of element in simulant)} \quad \text{(mass of element in treated liquid)}}{\text{(mass of element in simulant)}} \text{ x (100\%)}$$

$$\text{\% Removed} = \frac{\text{(concentration in simulant)} \quad \text{(concentration in treated waste)(MD)}}{\text{(concentration in simulant)}} \text{ x (100\%)}$$

For cerium in Batch 2 the 4 hour % Removed = ((26.4)-(2.33)(1.20)) / (26.4) x (100%) = 89.4%.

The removal of the radioactive isotope strontium-90 from the real waste is primarily due to the isotopic dilution that occurs because of the large addition of non-radioactive strontium as a reagent. The pilot precipitation experiments used non-radioactive simulants, so the isotopic dilution effect cannot be experimentally determined. However, the maximum possible decontamination will be obtained if complete mixing occurs, so that the isotopic concentration in the precipitated strontium solids is the same as the isotopic concentration in the dissolved strontium remaining in solution. This maximum decontamination can be calculated.

Pretend for the moment that a portion of the strontium in the simulant was the radioactive isotope Sr-90. The mass fraction of strontium 90, $f_{Sr\text{-}90}$, equals (mass of Sr-90 isotope)/(mass of all Sr isotopes).

Define a strontium mass dilution factor as shown below:

$$\text{MDSr} = \frac{(\text{mass of Sr in simulant} + \text{mass of Sr in all additions})}{(\text{mass of Sr in simulant})}$$

Assume there is 100% isotopic dilution, so that the mass fraction of Sr-90 in the precipitated solids equals the mass fraction of Sr-90 in the dissolved strontium remaining in the treated liquid.

Mass fraction of Sr-90 in treated liquid

$$= \frac{(\text{mass of Sr-90 in simulant})}{(\text{mass of all Sr in waste}) + (\text{mass of Sr added as reagent})}$$

$$= \frac{(f_{Sr\text{-}90})\,(\text{mass of all Sr in simulant})}{(\text{mass of all Sr in simulant}) + (\text{mass of Sr added as reagent})}$$

$$= \frac{(f_{Sr\text{-}90})}{MD_{Sr}}$$

The decontamination factor for the strontium-90 isotope is then:

$$DF_{Sr\text{-}90} = \frac{(\text{mass of Sr-90 in simulant})}{(\text{mass of Sr-90 in treated liquid})}$$

$$= \frac{(f_{Sr\text{-}90})\,(\text{mass of all Sr in simulant})}{(f_{Sr\text{-}90})\,(1/MD_{Sr})\,(\text{mass of all Sr in treated liquid})}$$

$$= \frac{(\text{mass concentration of Sr in simulant})\,(MD_{Sr})}{(\text{mass concentration of Sr in treated liquid})\,(\text{MD})}$$

$$= (DF_{Sr})\,(MD_{Sr})$$

Note that this result is independent of the value of the "pretended" mass fraction of Sr-90 in the simulant. (In fact, the Sr-90 decontamination factor will also be independent of the mass fraction of Sr-90 in the real waste as well, assuming 100% isotopic dilution.)

For Batch 2 there were 2.66 grams of strontium deliberately added as part of the makeup of the simulant. (Note: The amount of strontium added was erroneously reported as 2.69 in the Batch #2 interim report. It was originally believed that exactly half of the AN-107 simulant was added to each of Batch #1 and #2. A careful review of the logbook showed that very slightly more than half of the available simulant went into Batch #1, with the remainder going into Batch #2.) There were 4931 grams of strontium added in the strontium nitrate reagent solution. The Sr concentration added by recipe was therefore
(2.66 gms) / (795691 gms) = 3.35 μg/gm. The ADS-measured concentration four hours after the last reagent was added was 144 μg/gm.

MD_{Sr} = (2.66 gm + 4931 gm) / 2.66 gm = 1854

DF_{Sr} = (3.35) / [(144) (1.20)] = 0.0194

$DF_{Sr\text{-}90}$ = (0.0194) (1834) = 36

Note that this calculation used the recipe value of strontium in the simulant rather than the ADS values. Typical small levels of impurities in some of the chemicals added in large amounts could easily increase the strontium in the simulant from the theoretical 2.66 grams to 4 or 5 grams. In other words, the actual amount of strontium in the simulant is primarily a function of the purity of the other chemicals used in its makeup. But such a large amount of strontium is added as a reagent and precipitated out that the amount of strontium remaining dissolved in the liquid is solely dependent on the solubility of strontium carbonate in the treated liquid, not the amount originally in the simulant. The 2.66 grams of strontium deliberately added to the simulant to represent the strontium levels in the real waste must be used in the calculation if the $DF_{Sr\text{-}90}$ is to have any meaning relative to this precipitation process applied to the real waste.

Assuming 100% isotopic dilution, the % Removed for the "pretended" strontium-90

$$= \frac{(\text{mass of Sr-90 in simulant}) - (\text{mass of Sr-90 in treated waste})}{(\text{mass of Sr-90 in simulant})} \times (100\%)$$

$$= \frac{(f_{Sr\text{-}90})(\text{mass of Sr in simulant}) - (f_{Sr\text{-}90} / MD_{Sr})(\text{mass of Sr in treated liquid})}{(f_{Sr\text{-}90})(\text{mass of Sr in simulant})} \times (100\%)$$

$$= \frac{(\text{Sr concentration in simulant}) - (\text{Sr concentration in treated liquid})(MD/MD_{Sr})}{(\text{Sr concentration in simulant})} \times (100\%)$$

Again, this result is independent of the value of the "pretended" mass fraction of Sr-90 in the simulant, and the recipe value for the strontium in the simulant should be used in the calculation. For Batch 2,

the % $\text{Removed}_{\text{Sr-90}}$ = [(3.35) – (144)(1.20/1834)] / (3.35) x (100%) = 97.2 %

Since the amount of final glass product that has to be made depends on the amount of sodium added to the waste during processing as well as the amount originally in the waste, it is useful to introduce a waste sodium mass dilution factor defined as:

$$MD_{Na} = \frac{\text{(mass of Na in simulant + mass of Na in all additions)}}{\text{(mass of Na in simulant)}}$$

For the process used in Batch 2,
MD_{Na} = (84317 grams + 14907 + 873 grams) / (84317 grams) = 1.19.

The reagents added nineteen percent of the sodium in the treated liquid, requiring nineteen percent more glass to be made.

3.9 DISCUSSION OF RESULTS

3.9.1 Precipitation

Table 1-2 **(**shown previously) summarizes the key results and the major process variables. Following the discussion below, Table 3-13 through Table 3-18 detail the effects of the precipitation process on the cations and some anions that make up the simulants for batches 1 through 4. Figure 3-5 through Figure 3-15 plot the concentrations of the TRU surrogates, strontium, and other elements that changed significantly during the precipitation. As mentioned previously, no sample captured the rapid transient concentration of the reagents during addition. No attempt has been made to show these concentrations in the plots.

The precipitation process worked as expected to convert soluble ions to insoluble solids that could be filtered out of the resultant slurry. Based on the amount of dried solids collected from one-liter samples, the maximum insoluble solids content after precipitation for the AN-107 simulant was about 3.5 wt%.[1] Based on slurry samples collected after precipitation of batches 3 & 4 and submitted for immediate solids content analysis, the insoluble solid contents after precipitation ranged from 0.8 wt% to 1.5 wt% for the AN-102 simulant.[2]

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[1] The solids content for Batches 1 &2 must be considered maximum values only. The material collected by simple filtration contained dissolved salts that were left behind as contaminants to the insoluble solids and were included in the weight of solids after drying.
[2] The solids contents for Batches 3 & 4 were obtained with an analytical technique that accounted for the dissolved salts so are more accurate results of the true insoluble solids contents.

The effectiveness of the AN-107 simulant Sr/TRU precipitation reaction with strontium nitrate and sodium permanganate (with or without addition of caustic) was determined by the reduction in concentration of strontium and non-radioactive surrogate TRU elements Ce, La, and Nd in the slurry liquid four hours after the reagents were added.[3] All of the batches had over 80% of the Ce, La, and Nd removed from the initial slurry; the pulse jet mixed batch (4A) had over 90% of these elements removed.[4] The corresponding decontamination factors ranged from 5.2 to 10 for Ce, 5.8 to 22 for La, and 4.3 to 12 for Nd. The pulse jet mixed batch 4A at test conditions in Table 1-2 had the highest DF values.

The surrogate TRU element decontaminations found in this series of experiments are similar to those found in bench scale studies. Wilmarth et al. (19) previously reported correlations between La, Nd, and Am decontaminations that were discussed in the previous Batch #1 and #2 interim reports. Further work has shown that those correlations may not have been valid. At present, there is no direct correlation between the decontaminations of the surrogate TRU elements and the decontaminations of Am, Cm, or Pu.

The precipitation process will be very effective in removing the strontium-90 if there is a high degree of exchange between the strontium in the waste and the strontium added as a reagent. Assuming 100% isotopic mixing, calculations show at least 97% of the strontium-90 will be removed with any of the processing conditions studied in this series of experiments. The calculated strontium-90 DFs ranged from 36 to over 1000.[5] Lower levels of free hydroxide decrease the solubility of strontium carbonate, limiting the amount of strontium that remains in the treated liquid. The effect was fairly small with only one or two percent change in the calculated amount of strontium-90 that was removed.

Previous bench-scale experiments measured strontium-90 decontamination factors in the range of 30 to 100. Prior work by Nash et al. (11) found that complete isotopic mixing occurs even though the strontium carbonate precipitates very rapidly. This implies a very high degree of dynamic equilibrium allowing the strontium atoms in solution and the precipitated strontium atoms to exchange. It seems likely that in a large, completely unmixed tank, the physical separation of the precipitated solids from the majority of the liquid would slow down this exchange. There is no way to determine if complete isotopic mixing occurred in our much larger pilot scale experiments. However, the calculated removal of strontium in all batches was much higher than required to meet the immobilization regulatory requirements. The strontium-90 removal should be adequate even if there is limited isotopic mixing.

[3] The four hour results should be viewed in conjunction with Tables 3-12 through 3-17, as scatter in the analytical results is not readily apparent with a single point calculation.
[4] Note that these results are dependent upon the measured levels in samples. As discussed previously, samples for earlier batches 1 through 3 may have been compromised by delays in analysis due to innate instability. The samples for Batch 4A were stabilized or analyzed immediately to prevent errors due to instability.
[5] The reader is cautioned that a very large DF can be misleading. A DF of 100 represents removal of 99% of an element; a DF of 1000 represents removal of 99.9%, only an additional 0.9%.

The behavior of highly radioactive elements cesium-137 and technetium-99 are also of interest in waste treatment processes. Cs-132 is a non-radioactive isotope chemically identical to Cs-137 and would be expected to behave the same. It was included in the AN-107 simulant. Based upon the work of Darab and Smith (14), rhenium was selected as a nonradioactive surrogate for Tc-99 in the AN-107 simulant.[6] The results of the Batch #1 and #2 experiments using the AN-107 simulant indicated the technetium and cesium in the real waste will be unaffected by the precipitation process.

[6] Rhenium and cesium were added to allow use of the pilot precipitation filtrate in pilot scale ion exchange column tests by others. The planned testing was changed, so these elements were not added to the AN-102 simulant.

Table 3-13. Concentration of Selected Elements in Batch #1 Liquid Samples

BATCH #1 ANALYSIS WITH CONCENTRATIONS CORRECTED FOR MASS DILUTION													
								Total	Na	Sr			
Initial Mass of Simulant Slurry, grams								811974	86004	2.7			
Caustic Adjust:	None							0	0	0			
Reagents:	11910	grams strontium nitrate in			53370	grams water		65280	0	4931			
	5415	grams sodium permanganate in			36395	grams water		41810	877	0			
MD = Mass Dilution factor = $(G_{initial} + G_{reagents}) / (G_{initial})$								1.13	1.01	1815			
						Concentration (µg/gm)							
Sample Description			AN-107 Supernate Expected based on Mixed Amounts	AN-107 Simulant Supernate after dilution and solids only	AN-107 Simulant Supernate after Reagents Added					Amount Removed Based on 4 hr sample		Amount Removed based on 8 hr sample	
EDL Sample No.				1L	2L*MD	4L*MD	6L*MD	8L*MD	10L*MD	%	DF	%	DF
Time after Reagent Add (hrs)			N/A	N/A	0.125	0.5	2	4	8				
ADS Sample No.				169600	169627	169629	169631	169633	169635				
Idenity		Method											
Al		ICP-ES	196	386	670	134	61.1	148	74.7				
B		ICP-ES	17.7	56.0	83.8	23.8	<23	<23	<23				
Ba		ICP-ES	0	<1.5	<1.7	<1.7	<1.7	<1.7	<1.7				
Ca		ICP-ES	300	129	70.2	43.0	23.8	23.8	26.0				
Cd		ICP-MS	0	<1	<1.1	<1.1	<1.1	<1.1	<1.1				
Ce		ICP-MS	26.8	26.4	7.55	5.48	5.58	5.09	4.72	80.7	5.2	82.1	5.6
Cr		ICP-ES	89.3	93.0	82.6	70.2	75.8	75.8	75.8				
Cs		ICP-MS	9.42	10.4	10.4	8.51	9.72	10.1	10.0				
Cu		ICP-ES	15.3	22.0	101	128	29.4	60.0	120				
Fe		ICP-ES	857	1005	525	508	309	297	292				
K		ICP-ES	918	1420	1471	1200	1404	1381	1437				
La		ICP-MS	23.1	23.2	3.78	2.93	2.85	2.75	2.51	88.1	8.4	89.2	9.2
Mg		ICP-ES	12.7	51.0	18.1	17.0	12.5	14.7	13.6				
Mn		ICP-ES	285	294	318	287	384	411	440				
Na		ICP-ES	129326	110000	109340	86476	104813	106284	106398				
Nd		ICP-MS	48.6	43.5	10.0	7.47	6.78	6.11	5.22	85.9	7.1	88.0	8.3
Ni		ICP-ES	269	296	341	367	297	315	349				
P		ICP-ES	183	205	140	119	143	141	134				
Pb		ICP-ES	197	204	141	105	108	106	77.0				
Re		ICP-MS	9.37	11.0	11.5	9.10	11.1	11.1	10.6				
S		ICP-ES	1397	1650	1585	1347	1562	1573	1585				
Si		ICP-ES	12.1	47.0	38.5	44.1	<11	<11	23.8				
Sr		ICP-ES	3.35	5.00	22.2	8.26	6.00	6.00	4.53	99.9	1013	99.9	1342
Zr		ICP-ES	35.5	33.0	29.4	23.8	28.3	28.3	28.3				
Acetate		IEC		737	791	758	896	876	922				
Chloride (Cl^-)		IC		1011	1241	1255	953	1259	1289				
Citric Acid		IEC		4910	5259	4967	4838	4679	5002				
EDTA		IPC		2270	1939	1846	2319	2126	1771				
Fluoride		IC		2880	2587	2650	1962	2603	2689				
Formate ($HCOO^-$)		IEC		5862	9870	9825	8274	9924	10067				
Formate ($HCOO^-$)		IC		8453	7141	7057	8069	7755	8015				
Glycolic Acid		IEC		12857	13408	13317	13246	12932	13260				
HEDTA		IPC		579	422	394	499	431	380				
Nitrate (NO_3^-)		IC		105156	132052	137478	105778	132546	138730				
Nitrite (NO_2^-)		IC		35659	35847	36713	27593	36322	37265				
Oxalate ($C_2O_4^-$)		IC		880	2045	2065	1572	1985	2057				
Phosphate (PO_4^-)		IC		1147	878	847	662	723	831				
Sulfate (SO_4^-)		IC		4477	4852	4952	3795	4904	5146				
Note (1)	Sr DF is based on recipe amount and assumes 100% isotopic dilution takes place												

Table 3-14. Concentration of Selected Elements in Batch #2 Liquid Samples

BATCH #2 ANALYSIS WITH CONCENTRATIONS CORRECTED FOR MASS DILUTION														
								Total	Na	Sr				
Initial Mass of Simulant, grams								795691	84317	2.66				
Caustic Adjust:	34	liters @	1.5253	grams/ml				51860	14907	0				
MD = $(G_{Initial} + G_{NaOH}) / (G_{Initial})$								1.07	1.18	0				
Reagents:	11910	grams strontium nitrate in			53365	grams water		65275	0	4931				
	5389	grams sodium permanganate in			37271	grams water		42660	873	0				
MD = $(G_{Initial} + G_{NaOH+reagents}) / (G_{Initial})$								1.20	1.19	1852				
			Concentration (µg/gm)											
Sample Description			AN-107 Supernate Expected based on Mixed Amounts	AN-107 Simulant Supernate after dilution and solids only	AN-107 Simulant Supernate after caustic addition	AN-107 Simulant Supernate after Reagents Added					Amount Removed Based on 4 hr sample		Amount Removed Based on 8 hr sample	
EDL Sample no.			N/A	0L	1L*MD	2L*MD	4L*MD	6L*MD	8L*MD	10L*MD				
Time after Reagent Add (hrs)			N/A	N/A	N/A	0.125	0.5	2	4	8	%	DF	%	DF
ADS Sample No.				169600	170445	170446	170448	170450	170452	170454				
Identity		Method												
Al		ICP-ES	156	386	209	353	245	214	201	239				
B		ICP-ES	14.1	56.0	<22	<24	<24	<24	<24	111				
Ba		ICP-ES	0	<1.5	<1.6	<1.8	<1.8	<1.8	<1.8	<1.8				
Ca		ICP-ES	300	129	323	193	197	184	185	183				
Cd		ICP-ES	0	<5.0	<5.4	<6.0	<6.0	<6.0	<6.0	<6.0				
Ce		ICP-MS	26.8	26.4	26.2	3.81	3.43	2.94	2.80	2.41	89.4	9.4	90.9	11
Cr		ICP-ES	89.3	93.0	83.1	75.7	75.7	72.0	72.0	75.7				
Cs		ICP-MS	0	10.4	10.8	10.3	15.6	9.68	10.0	10.1				
Cu		ICP-ES	15.3	22.0	72.4	155	133	19.2	<10	63.6				
Fe		ICP-ES	857	1005	803	120	151	93.7	96.1	120				
K		AAK	918	1620	1404	1427	1407	1383	1418	1403				
K		ICP-ES	918	1420	1321	1393	1417	1381	1381	1357				
La		ICP-MS	23.1	23.2	23.9	2.62	2.43	2.19	2.09	1.93	91.0	11	91.7	12
Mg		ICP-ES	12.7	51.0	<11	<12	<12	<12	<12	<12				
Mn		ICP-ES	285	294	279	98.5	102	107	113	121				
Na		AANA	132009	95829	118017	120293	105174	108601	110822	108286				
Na		ICP-ES	132009	110000	125691	126087	129689	126087	127288	127288				
Nd		ICP-MS	48.6	43.5	47.2	7.39	6.81	6.12	5.82	5.51	86.6	7.5	87.3	7.9
Ni		ICP-ES	269	296	299	360	341	304	288	310				
P		ICP-ES	183	205	210	210	201	204	211	216				
Pb		ICP-MS	197	201	186	59.6	57.3	54.8	53.9	52.8				
Pb		ICP-ES	197	204	199	<96	<96	<96	<96	<96				
Re		ICP-MS	9.56	11.0	9.78	10.3	10.0	9.85	10.0	9.74				
S		ICP-ES	1396	1650	1832	2077	1981	1969	2077	2149				
Si		ICP-ES	12.39	47.0	40.5	31.2	32.4	<24	<24	<24				
Sr		ICP-ES	3.35	5.00	4.47	209	208	187	173	132	97.2	36	97.9	47
Zr		ICP-ES	35.5	33.0	<43	<48	<48	<48	<48	<48				
Acetate		IEC		737	792	832	726	739	745	716				
Carbonate (CO_3^{2-})				34411	44294	39400	40227	39028	39571	38336				
Chloride (Cl^-)		IC		1011	973	997	967	987	1004	971				
Citric Acid		IEC		4910	3726	5458	4884	4956	5107	5021				
EDTA		IPC		2270	1796	2121	2406	2025	2151	1978				
Fluoride		IC		2880	2245	2079	2063	2085	2101	2056				
Formate ($HCOO^-$)		IC		5862	5120	5434	5178	5381	5374	5207				
Glycolic Acid		IEC		12857	12800	11937	10924	10956	11811	11600				
HEDTA		IPC		579	350	381	572	429	425	405				
Nitrate (NO_3^-)		IC		105156	102983	121256	118437	108060	117856	115750				
Nitrite (NO_2^-)		IC		35659	27660	28610	27761	28285	28905	28090				
Oxalate ($C_2O_4^{2-}$)		IC		880	568	1314	1347	1416	1303	1267				
Phosphate (PO_4^{3-})		IC		1147	1302	1215	1126	1064	1098	1069				
Sulfate (SO_4^{2-})		IC		4477	4589	4690	4573	4644	4686	4533				
Note (1)	Sample 0L is before caustic addition and is actually the analysis of sample 1L collected during Batch #1.													
(2)	Sample 1L was taken after caustic addition but prior to other reagent additions.													

Table 3-15. Concentration of Selected Elements in Batch #3C Liquid Samples

BATCH #3C ANALYSIS WITH CONCENTRATIONS CORRECTED FOR MASS DILUTION													
								Total	Na	Sr			
Initial Mass of Simulant Slurry, grams								1127198	122714	2.8			
Caustic Adjust:	None							0	0	0			
$MD_{Na} = (G_{Initial} + G_{NaOH}) / (G_{Initial})$								1.00					
Reagents:	5944	grams strontium nitrate in			26635.07	grams water		32579	0	2461			
	4492	grams sodium permanganate in			26293.56	grams water		30785	728	0			
$MD = (G_{Initial} + G_{NaOH+reagents}) / (G_{Initial})$								1.06	1.01	894			
				Concentration (μg/gm)									
Sample Description				AN-102R2 Supernate Expected based on Mixed Amounts	AN-102R2 Simulant Supernate after dilution and solids only	AN-102R2 Slurry Filtrate after Reagent addition				Amount Removed based on 4 hr sample		Amount Removed based on 50 hr sample	
										%	DF	%	DF
Time after Reagent Add (hrs)				N/A	N/A	0.5	2	4	50				
ML Sample No.					02-9857	02-1228	02-1229	02-9858	02-1226				
Identity			Method										
Al			ICP-ES	7243	7040	7881	7881	6918	7873				
B			ICP-ES	21.7	36.9	72.9	70.4	28.8	71.8				
Ba			ICP-ES	0.00	<0.01	<0.008	<0.008	<0.011	<0.008				
Ca			ICP-ES	289	187	93.4	102.4	70.4	112				
Cd			ICP-ES	35.8	37.1	28.1	29.7	27.7	28.0				
Ce			ICP-ES	26.3	24.2	5.20	5.18	4.68	3.95	80.7	5.2	83.7	6.1
Co			ICP-ES	1.62	1.18	<0.008	<0.008	<0.011	<0.008				
Cr			ICP-ES	148	121	110	123	121	120				
Cu			ICP-ES	13.8	11.3	1.85	1.97	1.61	1.88				
Fe			ICP-ES	24.6	24.7	1.49	2.06	1.00	0.61				
K			ICP-ES	1173	1970	2332	2259	1774	2088				
La			ICP-ES	22.7	18.4	3.77	3.62	2.82	2.38	84.7	6.5	87.1	7.7
Mg			ICP-ES	0	3.83	<0.033	<0.033	<0.011	<0.033				
Mn			ICP-ES	17.2	13.5	2.96	3.95	4.08	5.72				
Mo			ICP-ES	26.6	29.8	24.9	25.8	23.7	24.8				
Na			ICP-ES	108706	89500	88559	90184	89039	106434				
Nd			ICP-ES	55.6	40.7	10.2	9.59	7.31	6.58	82.0	5.6	83.8	6.2
Ni			ICP-ES	246	161	163	171	147	162				
P			ICP-ES	1056	632	577	634	609	559				
Pb			ICP-ES	109	65.8	12.3	14.2	15.6	16.5				
S			ICP-ES	2486	13600	2689	2624	6591	2421				
Si			ICP-ES	5.89	30.8	27.1	30.6	27.4	27.9				
Sr			ICP-ES	2.44	0.135	40.6	41.5	17.3	20.3	99.2	126	99.1	108
W			ICP-ES	98.8	110	86.1	91.8	85.7	90.2				
Zn			ICP-ES	2.96	3.40	<0.008	<0.008	<0.581	<0.008				
Zr			ICP-ES	7.90	6.84	1.85	1.95	2.31	1.66				
Chloride (Cl^-)			IC-ANION		2420	2470	2437	2292	2413				
Fluoride			IC-ANION		1110	1113	1113	1009	1064				
Formate ($HCOO^-$)			IC-ANION		5000	4891	4915	4626	4875				
Nitrate (NO_3^-)			IC-ANION		88600	96684	95059	88299	95059				
Nitrite (NO_2^-)			IC-ANION		36100	37455	36561	34327	36561				
Oxalate ($C_2O_4^{2-}$)			IC-ANION		<380	886	<385	<380	869				
Phosphate (PO_4^{3-})			IC-ANION		1610	1641	1568	1352	1454				
Sulfate (SO_4^{2-})			IC-ANION		7110	7231	7150	6760	7069				
Note (1)	Sr DF is based on recipe amount and assumes 100% isotopic dilution takes place												
(2)	The last sample shown (50 hrs) was collected from the composite filtrate tank after the slurry had been concentrated to the maximum extent possible.												

Table 3-16. Concentration of Selected Elements in Batch #3B Liquid Samples

BATCH #3B ANALYSIS WITH CONCENTRATIONS CORRECTED FOR MASS DILUTION													
								Total	Na	Sr			
Initial Mass of Simulant Slurry, grams								1141253	121806	2.78			
Caustic Adjust:	32200	grams of solid sodium hydroxide						32200	18512	0			
$MD_{Na} = (G_{Initial} + G_{NaOH}) / (G_{Initial})$								1.03					
Reagents:	15963	grams strontium nitrate in			71534	grams water		87497	0	6609			
	8043	grams sodium permanganate in			47078	grams water		55121	1303	0			
$MD = (G_{Initial} + G_{NaOH+reagents}) / (G_{Initial})$								1.15	1.16	2377			
			Concentration (µg/gm)										
		Description	AN-102R2 Supernate Expected based on Mixed Amounts	AN-102R2 Slurry Filtrate after dilution and solids only	Slurry filtrate after Caustic addition	AN-102R2 Slurry Filtrate after Reagent addition				Amount Removed based on 2 hr sample		Amount Removed based on 27 hr sample	
		Time after Reagent Add (hrs)	N/A	N/A	N/A	0.5	2	4	27				
		Sample No.		02-1190 & 02-1544 averaged	02-1545	02-1228	02-1229	02-1858 Rerun	02-1226	N/A		N/A	
Identity		Method											
Al		ICP-ES	7230	7142	7897	8605	8605	7796	8596				
B		ICP-ES	21.7	33.6	36.2	79.6	76.8	30.3	78.4				
Ba		ICP-ES	0	<0.01	<0.1	<0.01	<0.01	<0.1	<0.2				
Ca		ICP-ES	289	281	290	102	112	73	122				
Cd		ICP-ES	35.8	21.9	25.2	30.7	32.4	22.6	30.6				
Ce		ICP-ES	26.3	29.5	23.0	5.7	5.7	<0.12	4.3	80.8	5.2	85.4	6.8
Co		ICP-ES	1.62	0.86	<1	<0.01	<0.01	<1	<0.01				
Cr		ICP-ES	148	110	114	121	134	119	131				
Cu		ICP-ES	13.8	11.7	13.6	2.02	2.15	3.11	2.1				
Fe		ICP-ES	24.6	26.4	25.4	1.62	2.24	<0.23	0.7				
K		ICP-ES	1171	2228	2540	2546	2466	2479	2280				
La		ICP-ES	22.6	22.9	16.9	4.12	3.95	<0.46	2.6	82.8	5.8	88.7	8.8
Mg		ICP-ES	0	<0.01	<0.1	<0.03	<0.03	<0.1	<0.03				
Mn		ICP-ES	17.2	10.3	9.4	3.2	4.3	<0.12	6.2				
Mo		ICP-ES	26.6	15	26.5	27.1	28.2	27.0	27.1				
Na		ICP-ES	106542	101920	116188	96690	98464	121084	116205				
Nd		ICP-ES	55.6	41.2	40.3	11.1	10.5	<0.12	7.2	74.6	3.9	82.6	5.7
Ni		ICP-ES	246	185	196	178	187	186	177				
P		ICP-ES	1059	650	355	630	692	630	610				
Pb		ICP-ES	109	77.5	89.2	13.5	15.5	26.3	18.0				
S		ICP-ES	2490	4282	2776	2936	2865	2814	2643				
Si		ICP-ES	5.90	26.1	32.1	29.5	33.4	30.2	30.5				
Sr		ICP-ES	2.44	3.12	25.5	44.4	45.3	55.7	22.2	99.4	128	99.7	261
W		ICP-ES	98.7	101	100	94.0	100.2	101	98				
Zn		ICP-ES	2.96	2.55	<0.1	<0.01	<0.01	<0.1	<0.01				
Zr		ICP-ES	7.88	6.87	2.32	2.02	2.1	<0.12	1.8				
Chloride (Cl^-)		IC-Anion		2415	2492	2697	2661	2564	2635				
Fluoride		IC-Anion		1194	1227	1215	1215	612	1162				
Formate ($HCOO^-$)		IC-Anion		5154	5202	5340	5367	5251	5322				
Nitrate (NO_3^-)		IC-Anion		88881	89288	105560	103786	112657	103786				
Nitrite (NO_2^-)		IC-Anion		35402	35250	40894	39918	41160	39918				
Oxalate ($C_2O_4^{2-}$)		IC-Anion		<390	<389	967	<444	<444	949				
Phosphate (PO_4^{3-})		IC-Anion		2086	2663	1792	1712	2572	1588				
Sulfate (SO_4^{2-})		IC-Anion		7206	7213	7895	7806	7327	7717				

Notes (1) Sr removals are based on recipe amount and assume 100% isotopic dilution

(2) Due to equipment problems, there was a several day delay in analyzing the 4 hour sample. During the delay the sample formed solids that could not be resuspended.

(3) The last sample shown (27 hrs) was collected from the composite filtrate tank after the slurry had been filtered to the maximum extent possible.

Table 3-17. Concentration of Selected Elements in Batch #3A Liquid Samples

BATCH #3A ANALYSIS WITH CONCENTRATIONS CORRECTED FOR MASS DILUTION											
								Total	Na	Sr	
Initial Mass of Simulant, grams								1049968	131776	6.2	
Caustic Adjust:	26100	grams of solid sodium hydroxide						26100	7502	0	
MDNa = $(G_{Initial} + G_{NaOH}) / (G_{Initial})$								1.02			
Reagents:	14793	grams strontium nitrate in			66293.5	grams water		81087	0	6125	
	7453	grams sodium permanganate in			43628.99	grams water		51082.5	1207	0	
MD = $(G_{Initial} + G_{NaOH+reagents}) / (G_{Initial})$								1.15	1.07	991	
			Concentration (µg/gm)								
		Sample Description	(1) AN-102R2 Supernate Expected based on Mixed Amounts	AN-102R2 Slurry Filtrate after dilution and solids only	AN-102R2 Slurry Filtrate after Caustic addition	AN-102R2 Slurry Filtrate after Reagent addition				(2) Amount Removed based on 4 hr sample	
Time after Reagent Add (hrs)			N/A	N/A	N/A	0.5	2	4	5	%	DF
ML Sample No.			N/A	02-1553	02-1555	02-1862	02-1863	02-1859	02-1860		
Identity		Method									
Al		ICP-ES	7230	6800	7779	7744	7526	6996	6950		
B		ICP-ES	21.7	23.9	29.4	29.5	29.1	21.6	22.1		
Ba		ICP-ES	0	<0.10	<0.1	<0.12	<0.12	<0.12	<0.12		
Ca		ICP-ES	289	297	313	60.0	64.4	70.2	81.6		
Cd		ICP-ES	35.8	20.7	25.9	20.1	20.4	17.0	17.0		
Ce		ICP-ES	26.3	23.7	21.3	1.59	1.68	3.84	3.82	83.8	6.2
Co		ICP-ES	1.62	<1.0	<1.02	<1.2	<1.2	<1.2	<1.2		
Cr		ICP-ES	148	103	117	116	116	107	106		
Cu		ICP-ES	13.8	13.9	14.0	1.02	1.02	2.49	3.12		
Fe		ICP-ES	24.6	30.9	29.6	0.73	1.01	0.35	3.25		
K		ICP-ES	1171	2280	2439	2497	2405	2394	2382		
La		ICP-ES	22.6	17.8	15.4	<0.46	<0.46	1.70	1.40	90.4	10
Mg		ICP-ES	0	<0.10	<0.1	<0.12	<0.12	<0.12	<0.12		
Mn		ICP-ES	17.2	9.01	7.80	<0.12	<0.12	<0.12	0.222		
Mo		ICP-ES	26.6		26.5	26.8	26.8				
Na		ICP-ES	106542	104000	114784	117375	119677	119677	118526		
Nd		ICP-ES	55.6	25.2	27.0	7.13	6.26	5.80	4.94	77.0	4.3
Ni		ICP-ES	246	174	201	188	188	165	161		
P		ICP-ES	1059	454	360	849	800	644	483		
Pb		ICP-ES	109	73.9	89.8	8.45	8.54	10.3	16.5		
S		ICP-ES	2490	2160	2736	2635	2612	2209	2209		
Si		ICP-ES	5.90	37.3	34.3	29.6	29.5	26.6	29.9		
Sr		ICP-ES	2.44	13.2	10.7	186	174	152	120	97.4	38
W		ICP-ES	98.7	92.1	98.9	95.7	96.0	92.7	93.0		
Zn		ICP-ES	2.96	<0.10	<0.1	<0.12	<0.12	<0.12	<0.12		
Zr		ICP-ES	7.88	2.41	2.69	<0.12	<0.12	<0.12	<0.12		
Chloride (Cl^-)		IC-Anion		2162	2539	2560	2578	2560	2624		
Fluoride (Fl^-)		IC-Anion		1132	<415	<446	<446	532	490		
Formate ($HCOO^-$)		IC-Anion		4860	5094	4987	4897	4897	5091		
Nitrate (NO_3^-)		IC-Anion		83824	89336	100801	99909	97233	98503		
Nitrite (NO_2^-)		IC-Anion		33750	35813	36663	36663	35593	36639		
Oxalate ($C_2O_4^{2-}$)		IC-Anion		<368	<391	<446	<446	1508	1003		
Phosphate (PO_4^{3-})		IC-Anion		2066	2954	2426	1793	1624	1482		
Sulfate (SO_4^{2-})		IC-Anion		6581	7170	7261	7226	7136	7356		
Note (1)	These values were assumed to be identical to Batch #3B values, and were not calculated explicity.										
(2)	Sr removal values are based on recipe amount and assume 100% isotopic dilution takes place										

Table 3-18. Concentration of Selected Elements in Batch #4A Liquid Samples

BATCH #4A ANALYSIS WITH CONCENTRATIONS CORRECTED FOR MASS DILUTION												
								Total	Na	Sr		
Initial Mass of Simulant, grams								749173	96775	1.83		
Caustic Adjust:	23	liters of 50 wt% @		1.5253	grams/ml			35082	10084	0		
MDNa = (Ginitial + GNaOH) / (Ginitial)								1.05	1.10			
Reagents:	11063	grams strontium nitrate in			49576	grams water		60639	0	4580		
	5574	grams sodium permanganate in			32627	grams water		38201	903	0		
MD = (Ginitial + GNaOH+reagents) / (Ginitial)								1.18	1.11	2509		
			Concentration (µg/gm)									
Sample Description			(1) AN-102R2 Supernate Expected based on Mixed Amounts	AN-102R2 Slurry Filtrate after dilution and solids only	AN-102R2 Slurry Filtrate after Reagents added				Amount Removed based on 4 hr sample		Amount Removed based on 22 hr sample	
									%	DF	%	DF
Time after Reagent Add (hrs)			N/A	0	0.5	2	4	22				
ML Sample No.				03-0579	03-0580	03-0581	03-0582	03-0583				
Identity		Method										
Al		ICP-ES	7230	7097	7647	7707	7758	8697				
B		ICP-ES	21.7	26.2	27.3	28.2	27.8	37.7				
Ba		ICP-ES	0									
Ca		ICP-ES	289	348	120	127	124	63.4				
Cd		ICP-ES	35.8									
Ce		ICP-ES	26.3	17.8	3.19	2.32	1.77	1.81	90.1	10	89.8	9.8
Co		ICP-ES	1.62									
Cr		ICP-ES	148	103	108	111	110	124				
Cu		ICP-ES	13.8	18.3	2.08	4.14	6.25	9.40				
Fe		ICP-ES	24.6	18.3	1.11	0.95	1.05	1.03				
K		ICP-ES	1171	1894	2096	2095	2098	2119				
La		ICP-ES	22.6	16.4	1.44	1.00	0.74	0.79	95.5	22	95.2	21
Mg		ICP-ES	0									
Mn		ICP-ES	17.2	13.6	8.39	11.2	13.7	15.3				
Mo		ICP-ES	26.6	19.7	21.0	21.4	21.4	25.1				
Na		ICP-ES	106542	101721	92830	120913	120563					
Nd		ICP-ES	55.6	30.8	5.05	3.38	2.55	2.50	91.7	12	91.9	12
Ni		ICP-ES	246	112	109	111	112	129				
P		ICP-ES	1059	915	956	969	966	1023				
Pb		ICP-ES	109	48.5	6.65	11.0	11.8	11.9				
S		ICP-ES	2490	2621	2794	2852	2779	2764				
Si		ICP-ES	5.90	27.7	26.1	27.2	26.5	33.4				
Sr		ICP-ES	2.44	30.3	132	102	84.9	90.3	98.6	72	98.5	68
W		ICP-ES	98.7									
Zn		ICP-ES	2.96	5.35	5.16	4.69	4.55	5.27				
Zr		ICP-ES	7.88	5.57	1.56	1.26	1.15	1.25				
Note (1)	These values were assumed to be identical to Batch #3B values, and were not calculated explicity.											
(2)	Sr DF is based on recipe amount and assumes 100% isotopic dilution takes place											
(3)	The last sample shown (22 hrs) was collected from the precipitation tank after the 18 hour cool down period but before XF filtration was started. It was not a composite filtrate sample.											

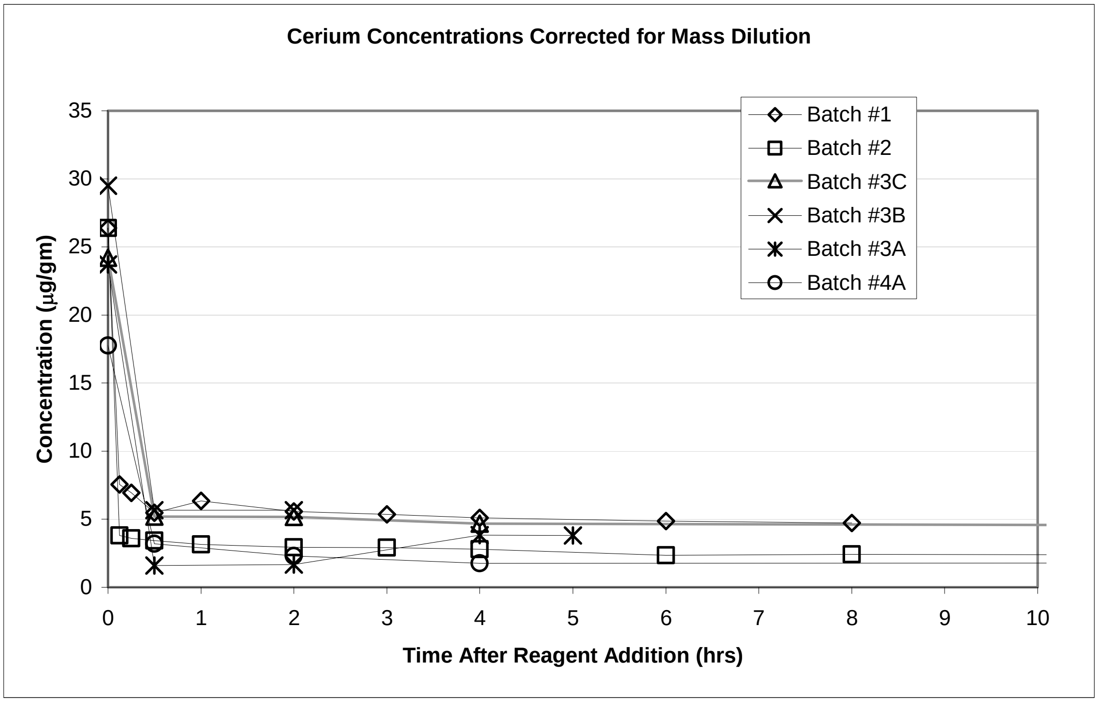

Figure 3-5. Cerium Concentrations for All Batches

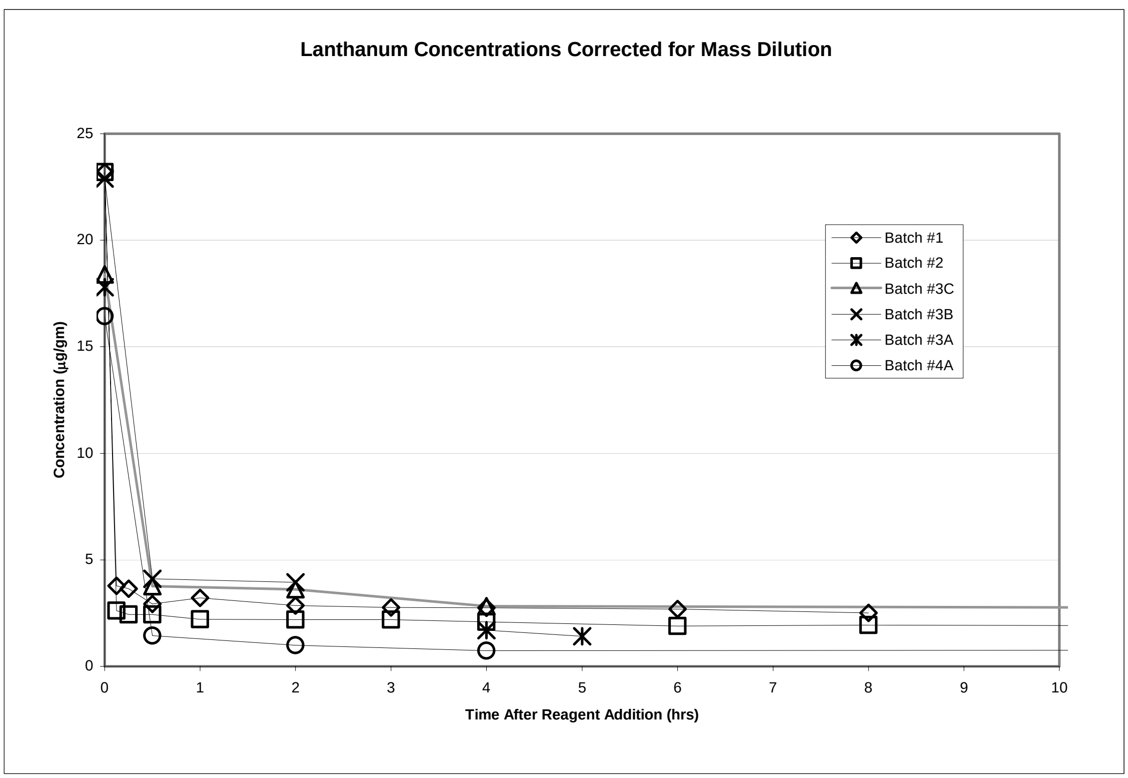

Figure 3-6. Lanthanum Concentrations for All Batches

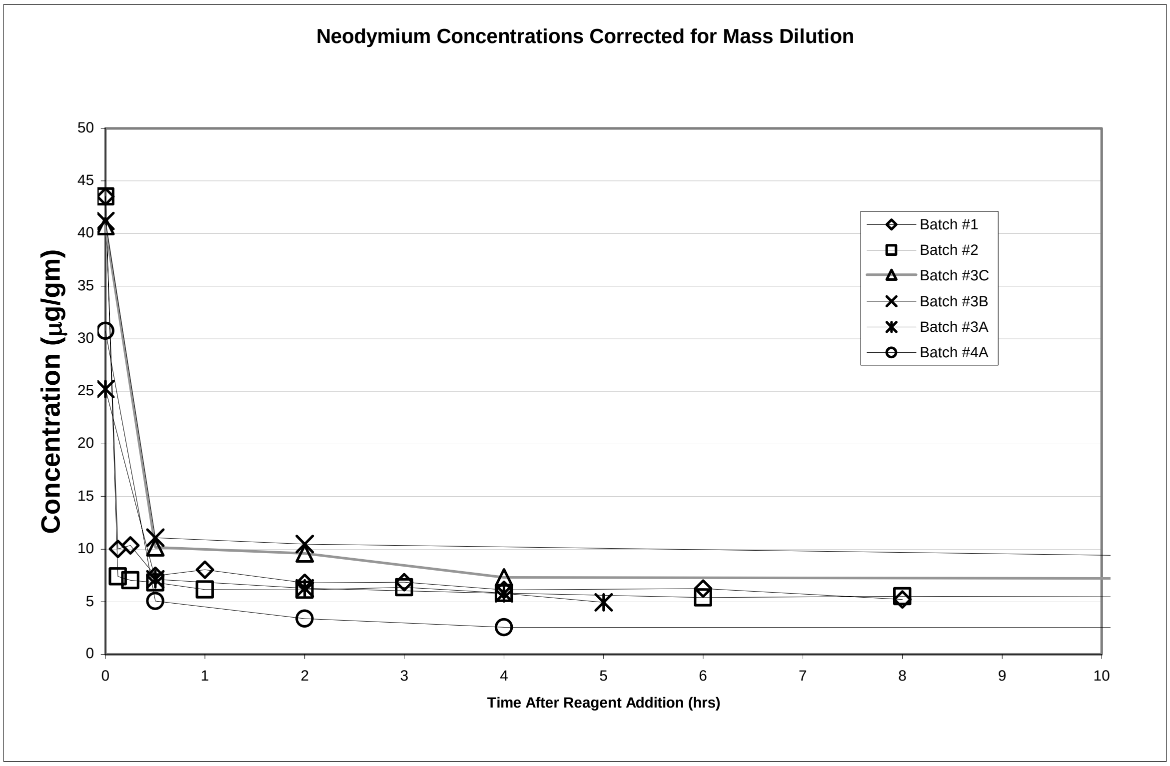

Figure 3-7. Neodymium Concentrations for All Batches

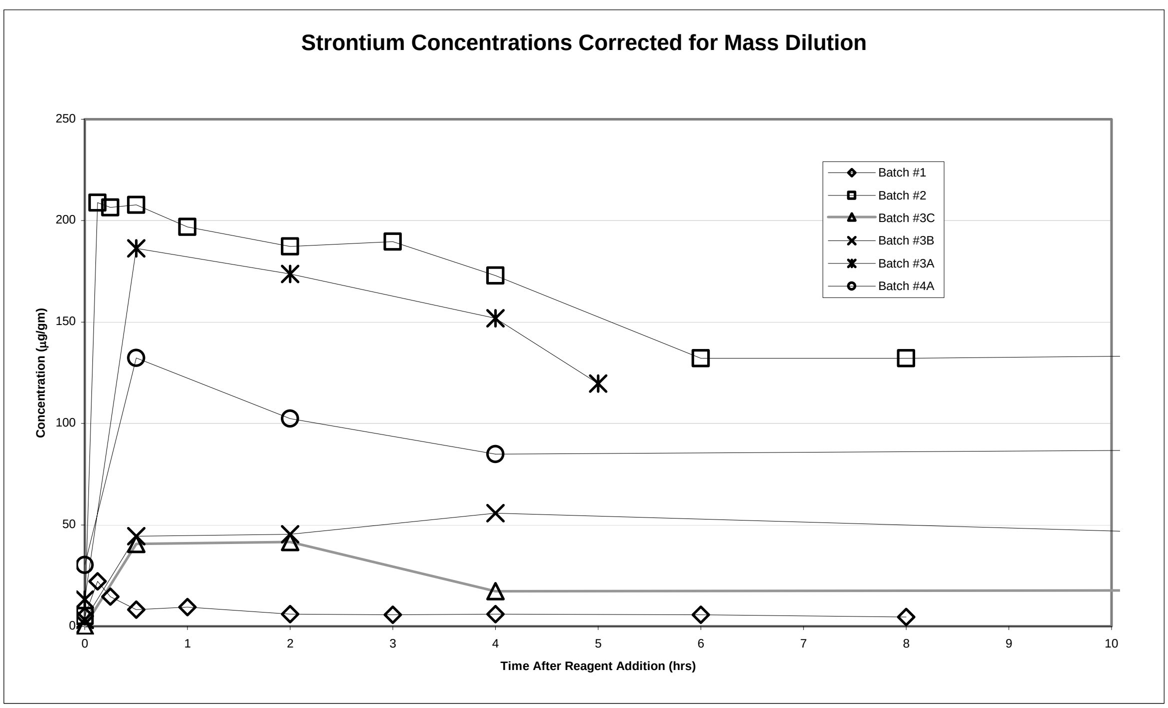

Figure 3-8. Strontium Concentrations for All Batches

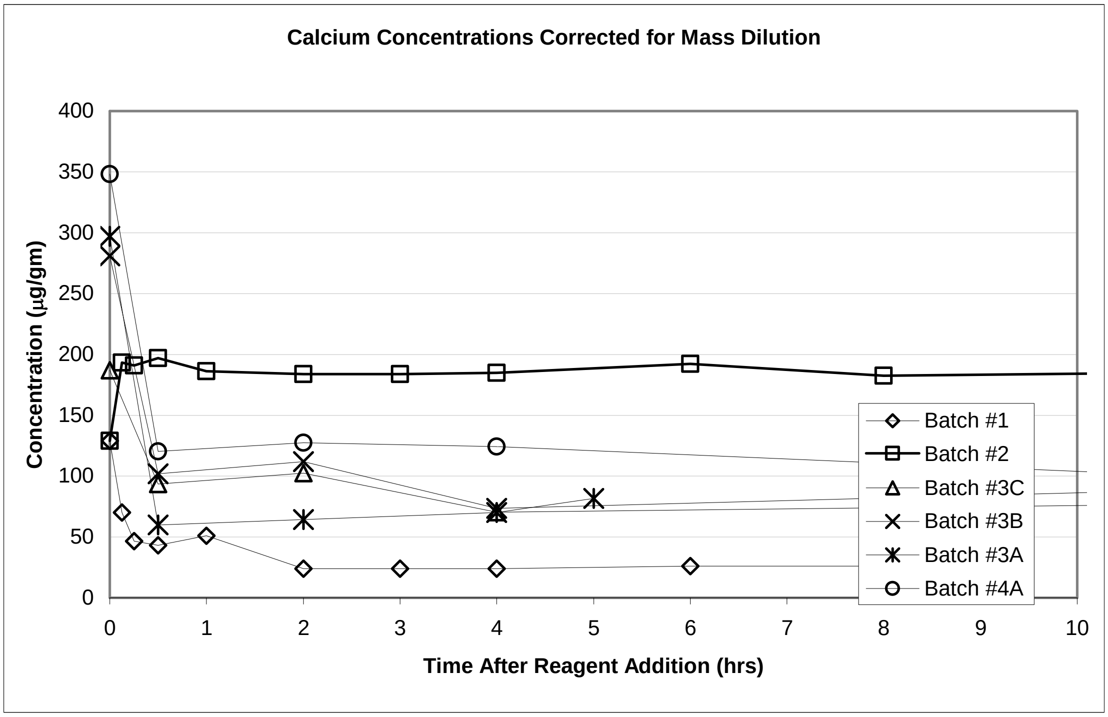

Figure 3-9. Calcium Concentrations for All Batches

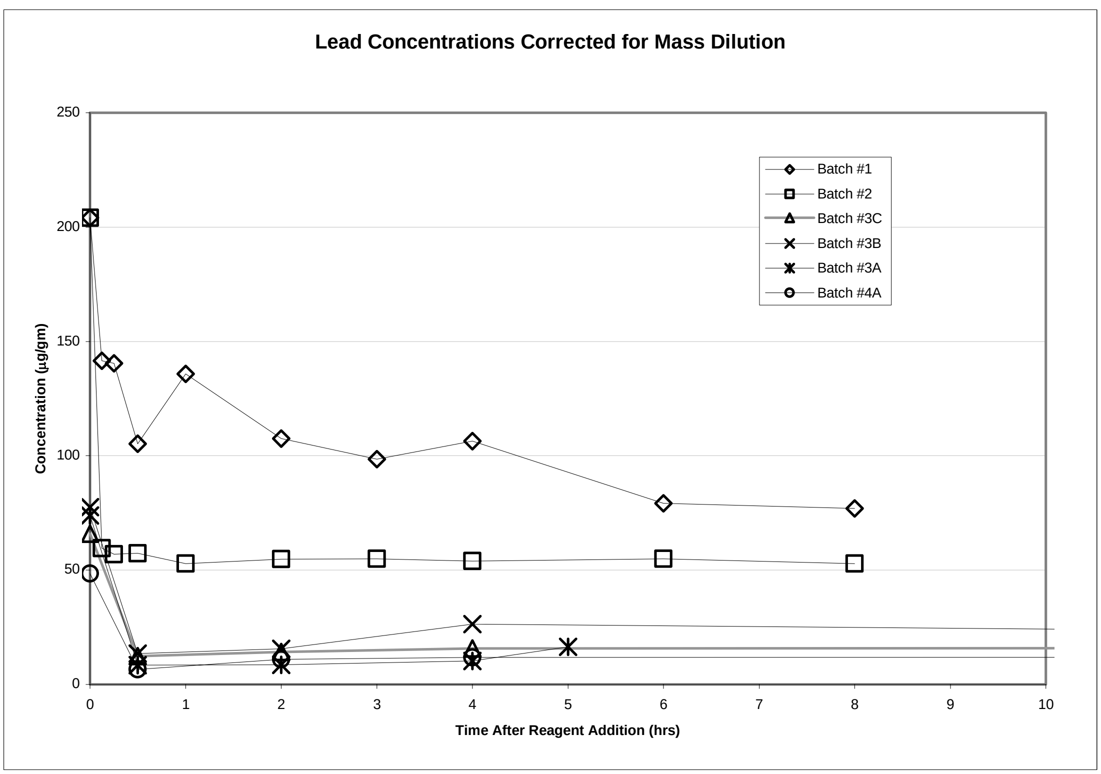

Figure 3-10. Lead Concentrations for All Batches

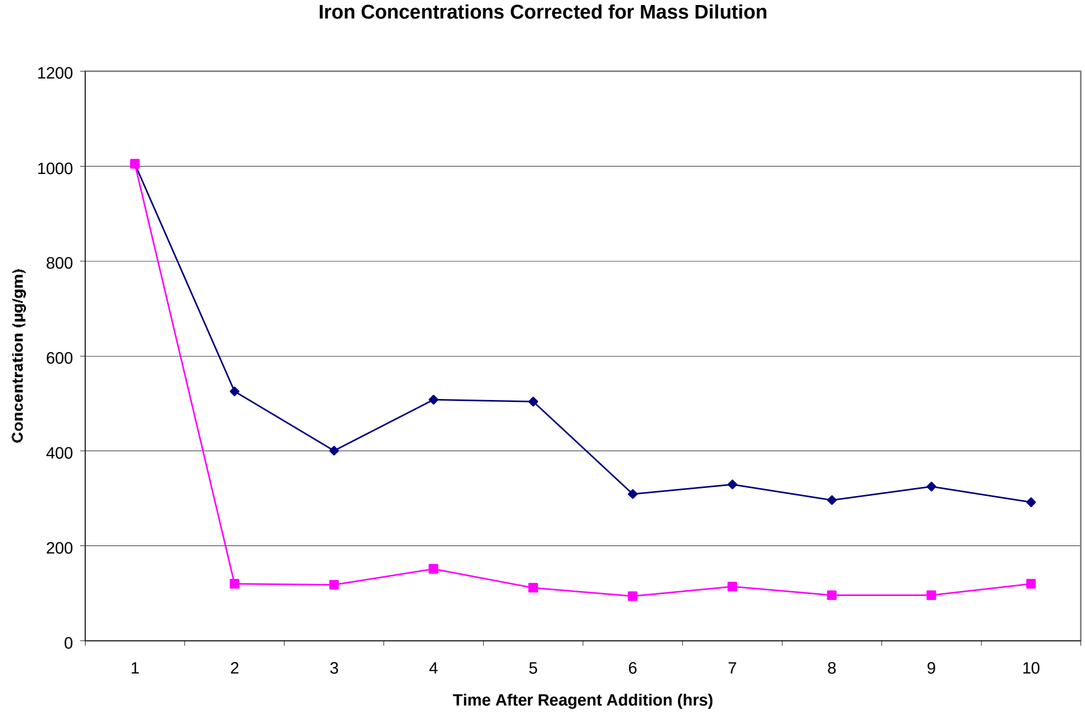

Figure 3-11. Iron Concentrations for Batches #1 and #2

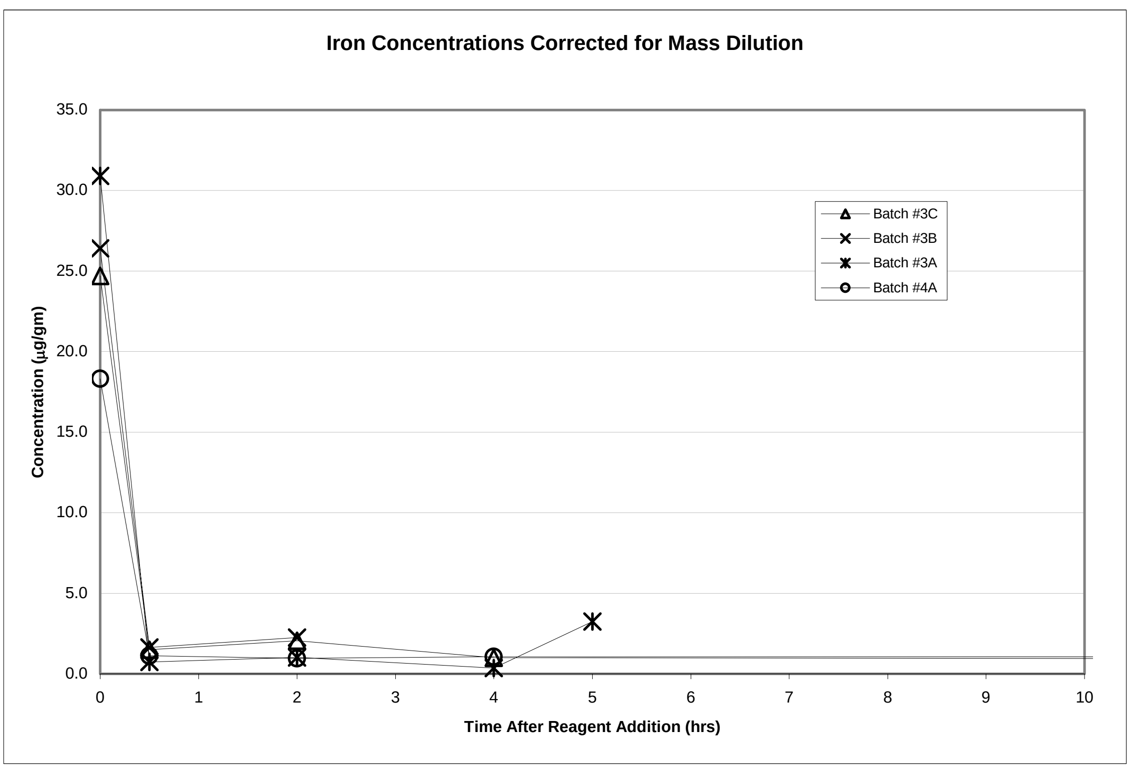

Figure 3-12. Iron Concentrations for Batches #3 and #4

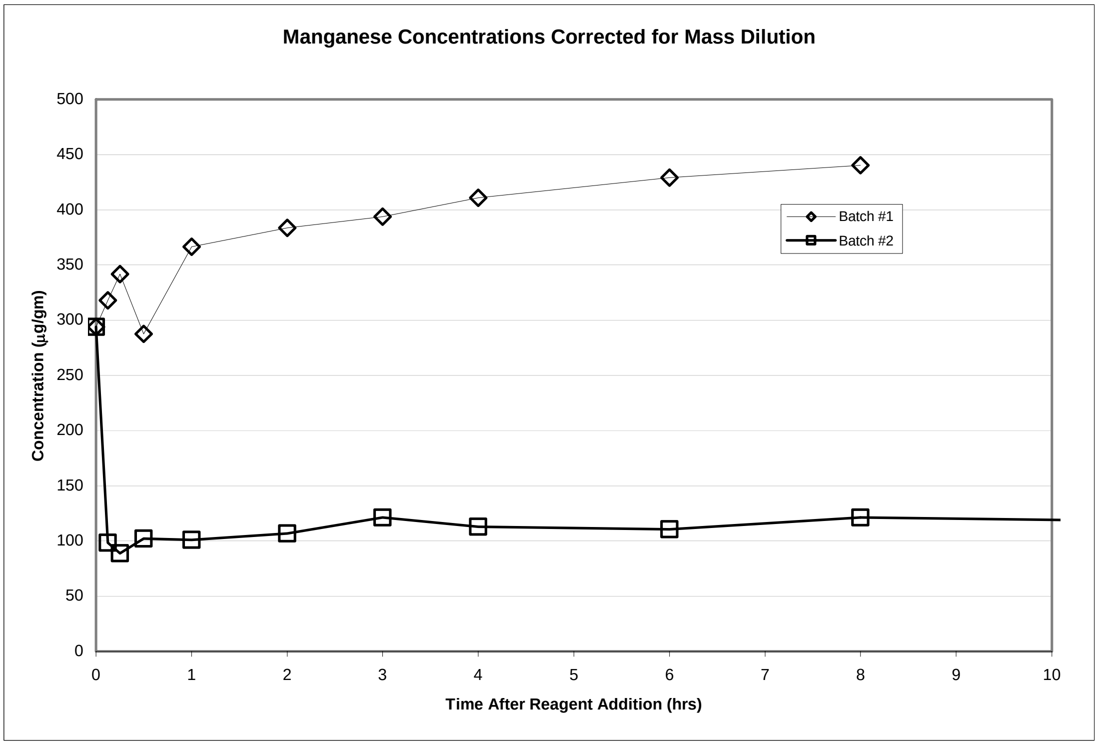

Figure 3-13. Manganese Concentrations for Batches #1 and #2

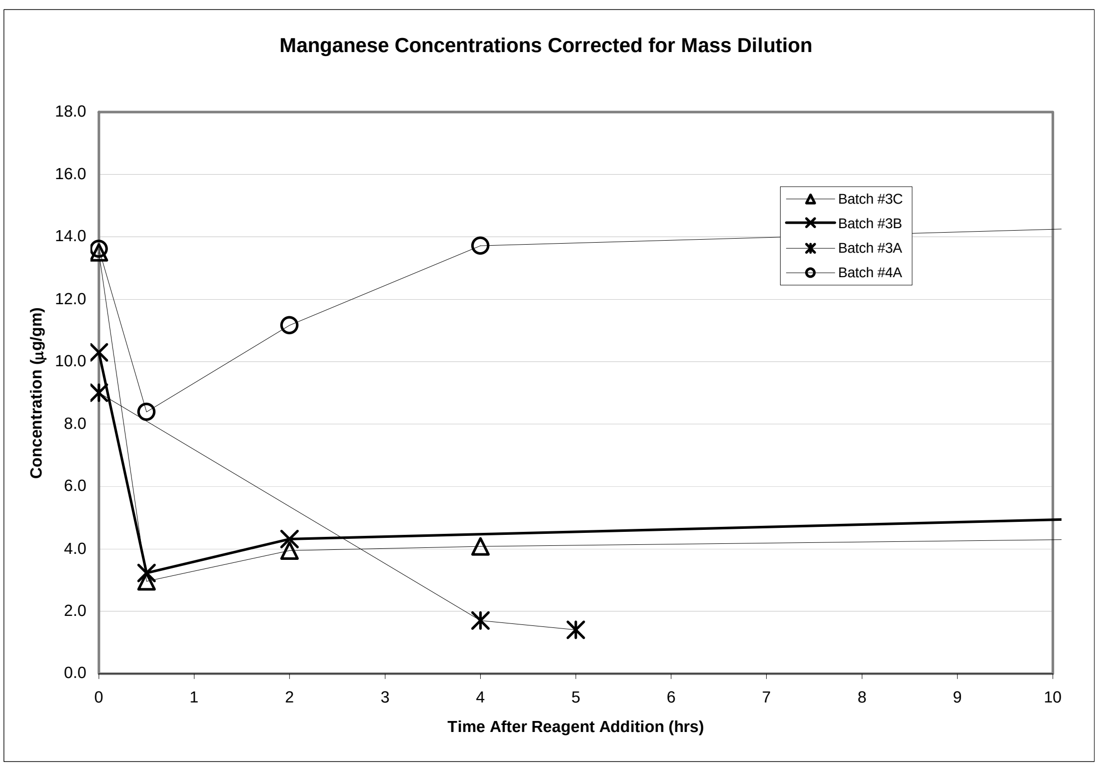

Figure 3-14. Manganese Concentrations for Batches #3 and #4

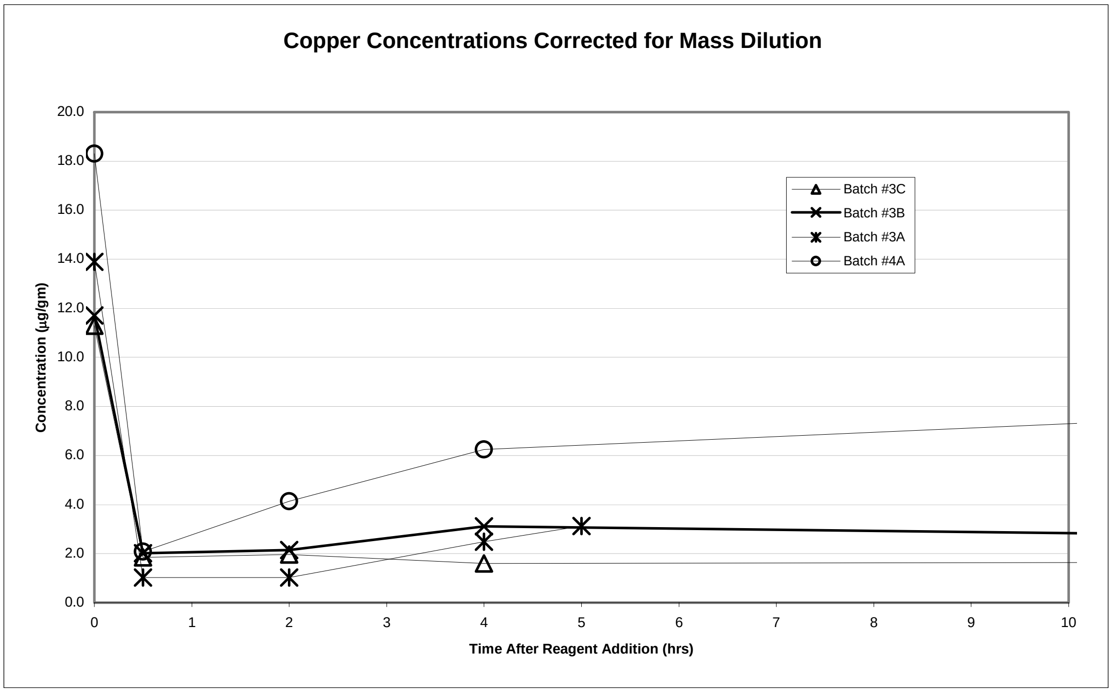

Figure 3-15. Copper Concentrations for Batches #3 and #4

A sample of the Batch #1 slurry[7] collected in a drum for later use in other experiments was taken about 2 months after precipitation and sent for particle size analysis. The microtrac analysis (Appendix I Fig. I-1) showed that only 10 v% of the particles were less than 1.14 micron, 50 v% were less than 2.92 micron, and 95 v% were less than 12.5 micron. Table 3-19 summarizes the particle distributions obtained after precipitation for other batches. Plots of all microtrac data obtained are included in Appendix I.

Table 3-19. Summary of Particles-Size Distributions after Batch Precipitation

Batch	10 v%	50 v%	95 v%	Appendix I Figure
1	1.14	2.92	12.5	I-1
2	1.04	2.15	5.50	I-2
3C	1.89	10.3	36.9	I-14
3B	2.30	5.43	25.1	I-23
3A	2.51	8.73	27.3	I-39
4A	Microtrac of slurry sample not performed.			

[7] The Batch #1 interim report incorrectly stated that this sample was collected from a filtrate drum instead of a slurry drum.

3.9.2 Filtration

A Test Specification was not provided for the pilot precipitation work. The approved Task Plan simply stated that the crossflow filter would be used to demonstrate filterability of the slurry, and a filtration matrix was not specified. At the time Batch #1 and #2 were run, firm operating conditions for the crossflow filter were not established. In a previous study, Duignan (17) recommended an axial velocity of at least 12 ft/sec and a transmembrane pressure of 30 to 55 psid. The conditions chosen for filtration of Batch #1 and #2 bracketed these conditions. In hindsight the filtration conditions chosen by the task leader were not maintained long enough to obtain definitive data in the ranges best matching currently planned plant operation conditions of 12 ft/sec and 40 psid. The limited amount of data shown in the plots below had to be extrapolated appreciably to provide the values reported in the tables for Batch #1 and #2.

Later batches were precipitated and filtered after plant design and operating conditions were much more firm, and the filtration studies were more complete. After precipitation, the resultant slurry from Batches #3C, #3B, #3A, and #4A were handed over to Duignan for filtration under a separate task plan written to meet a RPP test specification. The filtering behavior for Batches #3C, #3B, #3A, and #4A was thoroughly reported by Duignan (21) and won't be discussed further here.

For Batches #1 and #2, the precipitated feed was transferred to the Crossflow Filter Test Rig and an abbreviated filtration study was made using the following feeds:

- DIF water before filtering simulant slurry
- AN-107 precipitated simulant slurry
- DIF water after cleaning to confirm that the cleaning performed was adequate to restore filter function

The results of filtration tests with the AN-107 precipitated simulant slurry are shown in Table 3-20 and Table 3-21. The velocity shown is based on seven tubes with a nominal ID of 3/8 inch and the slurry loop (SL) flow measured with a magnetic flow meter. Differential pressures are measured between the filter slurry headers and filtrate ports at both the top and bottom ends of the filter. The transmembrane pressure (TMP) is the calculated average of these two differential pressure measurements. The filtrate flow (flux rate) is the total flow from the filtrate housing (measured by a magnetic flow meter in gpm) divided by the 2.29 ft^2 inside surface area of the filter. The filtrate flow rates shown were corrected to a filtration temperature of 25 ^oC by multiplying by the correction factor $CF = e^{[(2500)(1/(273+\text{Slurry Temperature})-1/298)]}$. The raw data collected during filtration is included in Excel format on the report CD-ROM. The first page of each filtration data file is included in Appendix K to describe what data is logged and to show the file format.

A Test Specification was not provided for the pilot precipitation work. The approved Task Plan simply stated that the crossflow filter would be used to demonstrate filterability of the slurry, and a filtration matrix was not specified. In hindsight the filtration conditions chosen by the task leader were not maintained long enough to obtain definitive data in the ranges best matching planned plant operation. The limited amount of data shown in Figure 3-16 and Figure 3-17 had to be extrapolated appreciably to provide the values reported in Table 3-20 and Table 3-21.

Table 3-20. Crossflow Filter Operations Data with Batch #1 Precipitated Slurry

Velocity (ft/sec)	TMP (psi)	Filtrate Flow (gpm/ft^2)
4.3	36.2	0.02
4.3	50.7	0.02
12.2	33.5	0.03
20.8	29.2	0.05

Table 3-21. Crossflow Filter Operations Data with Batch #2 Precipitated Slurry

Velocity (ft/sec)	TMP (psi)	Filtrate Flow (gpm/ft^2)
9.8	51.2	0.026
13.2	45.2	0.035
17.4	44.2	0.038
18.3	21.1	0.028

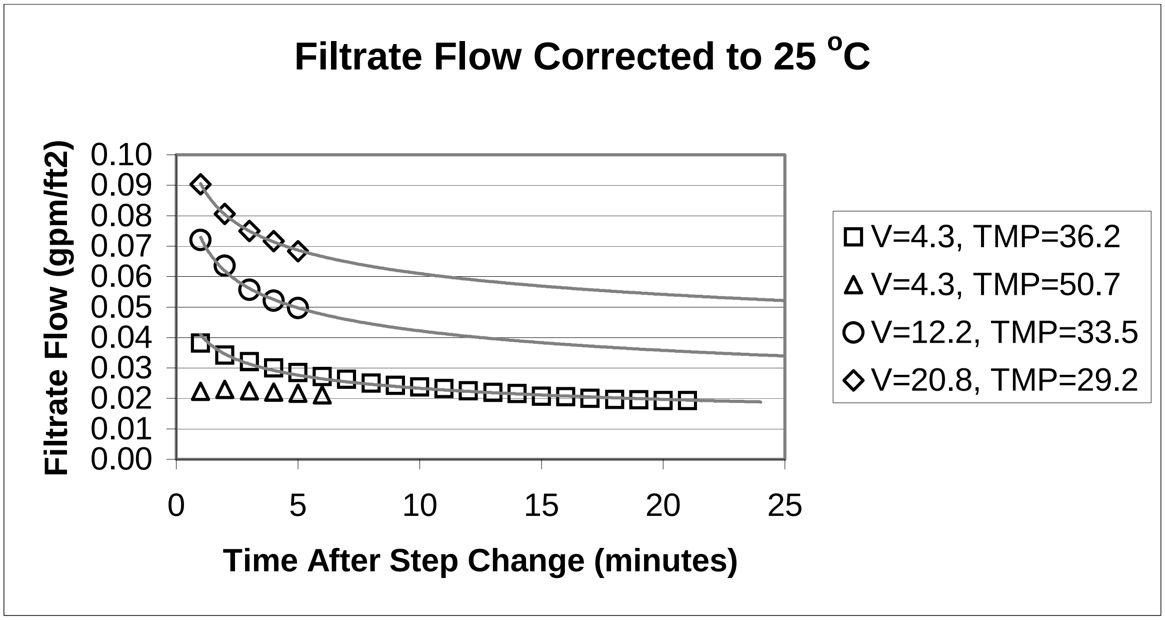

Figure 3-16. Filtrate Production Rate Data for Batch #1

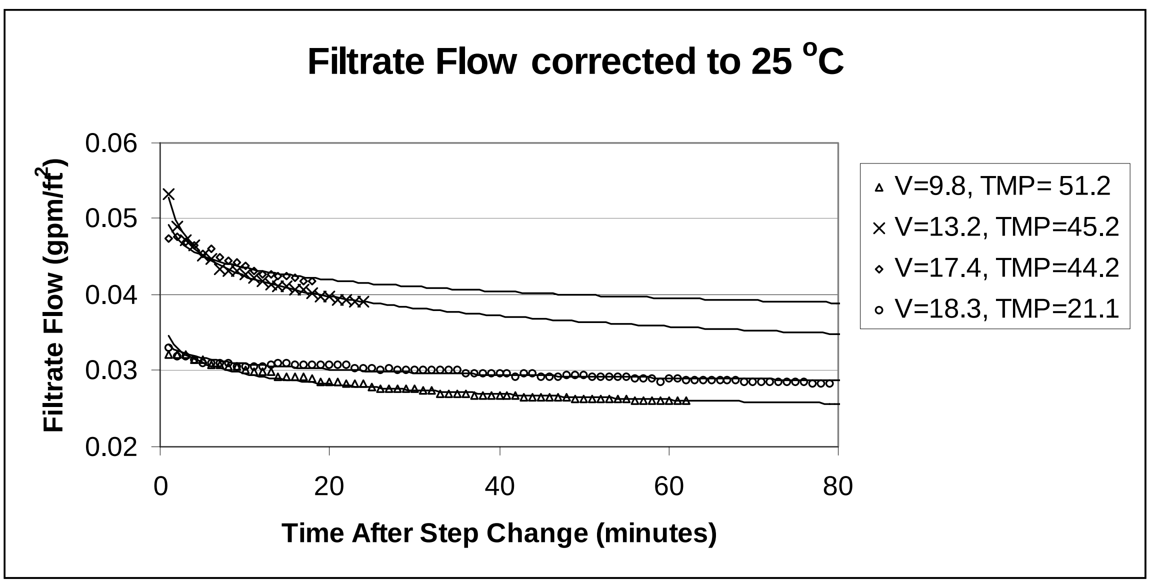

Figure 3-17. Filtrate Production Rate Data for Batch #2

These filtrate rates are similar to those reported by Duignan (17), especially considering the insoluble solids content of about 3% in this study was higher than the 2% in his study. He measured 0.03 gpm/ft^2 at V=8.9 ft/sec and TMP=32.1 psid. The lower values of 0.02 gpm/ft^2 at V=4.3 and TMP=36.2 measured in the Batch #1 experiment would be expected because of the effect of lower velocity. He found the flux to be fairly insensitive to the transmembrane pressure in the 30 to 55 psid range; the filtrate flow rates measured at V=4.3 ft/sec in this study were the same even though the transmembrane pressure varied from 36 to 51 psid.

The 0.026 gpm/ft^2 at V=9.8 and TMP=51.2 measured in the Batch #2 experiment is in good agreement with Duignan's data considering the higher solids content. The Batch #1 experiment measured a flux of about 0.03 gpm/ft^2 at 12.2 ft/sec and TMP=33.5 psid and the Batch #2 experiment measured a flux of about 0.035 gpm/ft^2 at V=13.2 ft/sec and TMP = 45.2 psid. These results compare well to Duignan's 0.04 gpm/ft^2 at V=12.3 ft/sec and TMP=51.1 psid. The 0.05 gpm/ft^2 flux for Batch #1 at V=20.8 and TMP=29.2 is a little lower than expected compared to his 0.07 gpm/ft^2 flux at the lower velocity of 15.4 ft/sec and similar TMP of 30.0 psid. Likewise, the 0.038 gpm/ft^2 flux for Batch #2 at V=17.4 and TMP=44.2 is lower than expected compared to his 0.052 gpm/ft^2 flux at the lower velocity of 15.3 ft/sec and lower TMP of 29.6 psid. These flux differences are in the right direction considering the difference in solids concentration.

The filtrate fluxes found in the Batch #1 experiment were consistent with the study of Hallen et al. (18). The filtrate fluxes found in the Batch #2 experiment were slightly higher than obtained in the study of Hallen et al. (18) under similar but not exactly the same conditions. The fluxes reported in their work are averages over the period from 10 minutes to 60 minutes after starting filtration; they were: 0.019 gpm/ft^2 at 9.0 ft/sec and 50 psid, 0.025 gpm/ft^2 at 12.2 ft/sec and 30 psid, and 0.024 gpm/ft^2 at 13.1 ft/sec and 49 psid.

After collecting the abbreviated filter performance data in the Batch #1 experiment, filtration was continued on the day shifts primarily to collect a drum of filtrate for subsequent use in other RPP studies. Although filter fluxes of about 0.05 gpm/ft^2 were achieved during the brief filter performance testing, long-term operation at the high axial flow-high transmembrane pressure conditions was not possible due to pump heat buildup. (Additional heat removal capacity was added to the rig for Batches #3 and #4.) Sustained operation at 25 ^{o}C could be maintained with the filter tube velocity set at about 16 ft/sec and the transmembrane pressure set at about 42 psid. The filtrate production achieved with AN-107 precipitated simulant under these conditions and with infrequent backpulsing was about 0.02 gpm/ft^2. Figure 3-18 shows a typical set of data taken during dewatering. Hallen et al. (18) also measured 0.021 gpm/ft^2 average flux during dewatering with similar conditions of 11.6 ft/sec velocity and 48 psid transmembrane pressure.

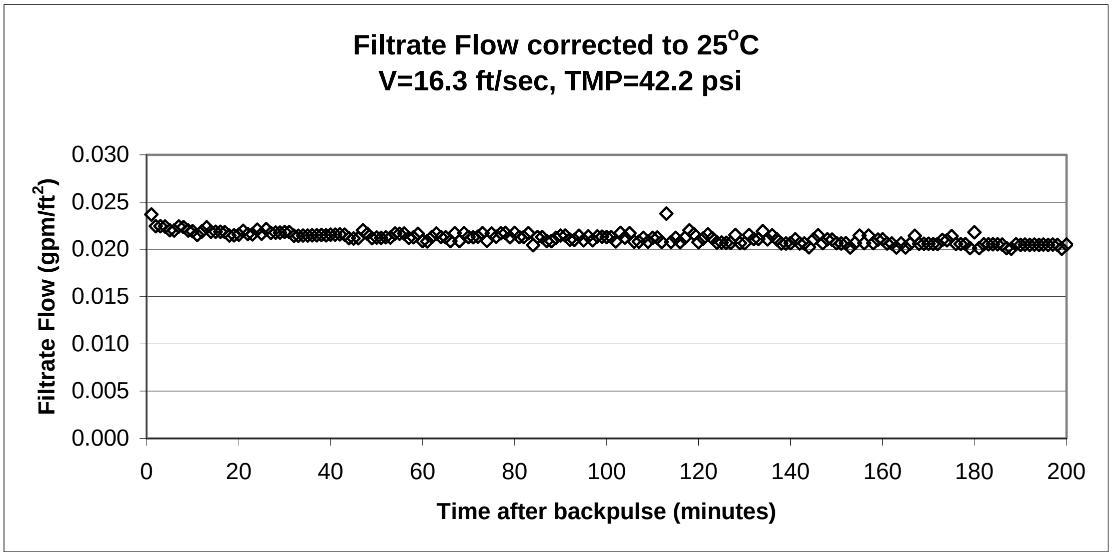

Figure 3-18. Crossflow Filter Filtrate Production with Batch #1 Precipitated Simulant Slurry

After collecting the abbreviated filter performance data in the Batch #2 experiment, filtration was continuous until the volume of slurry was reduced to about 70 liters. Operation at 25 ^{o}C was maintained with the filter tube velocity set at about 16 ft/sec and the transmembrane pressure set at about 45 psid. The filtrate production achieved with Batch #2 precipitated simulant under these conditions and with infrequent backpulsing was about 0.03 gpm/ft^2. Figure 3-19 shows a typical set of data taken early during dewatering. Figure 3-20 shows typical data taken after the slurry volume was reduced from 764 liters to about 70 liters. The flux with the concentrated slurry dropped to about 0.018 gpm/ft^2.

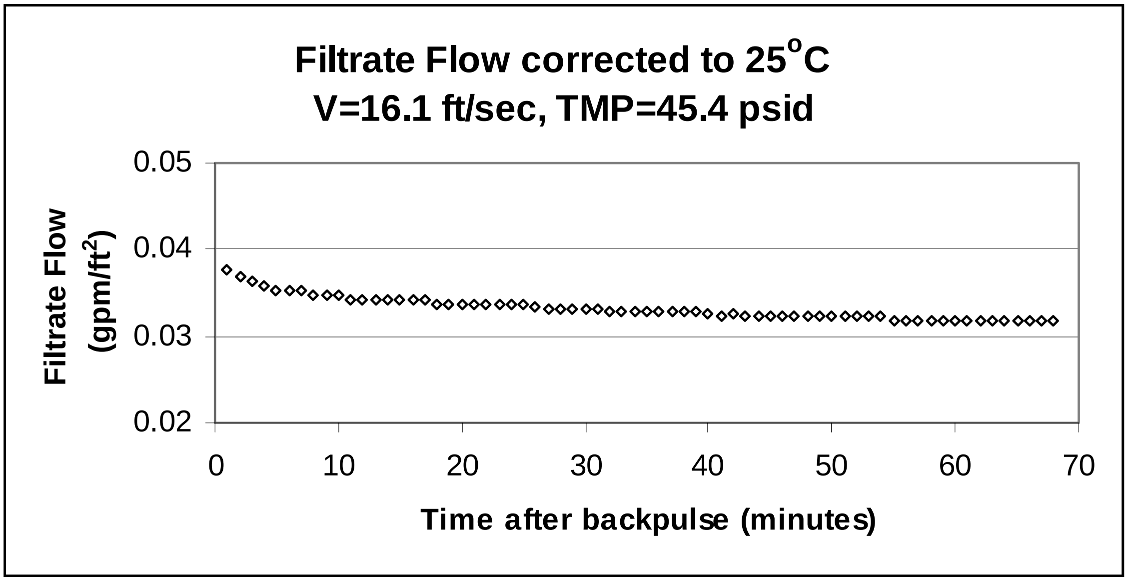

Figure 3-19. Crossflow Filter Filtrate Production with Batch #2 Precipitated Simulant Slurry Early During Dewatering

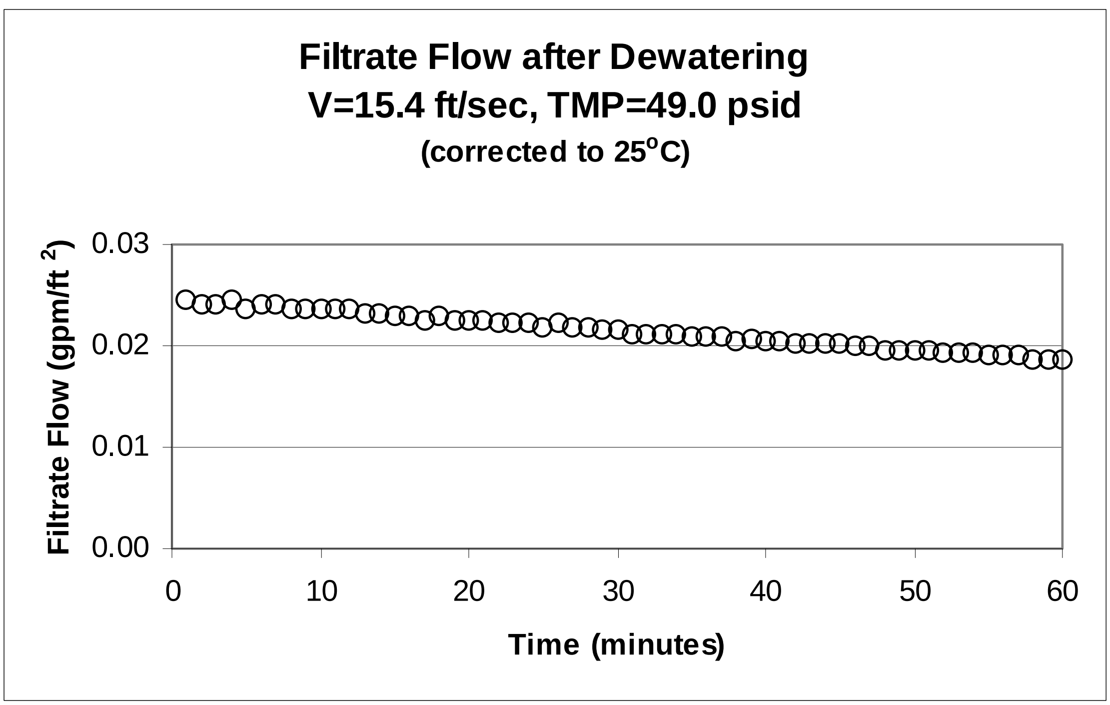

Figure 3-20. Crossflow Filter Filtrate Production with Batch #2 Precipitated Simulant Slurry at the End of Dewatering

After sufficient filtrate was collected in the Batch #1 experiment, the Crossflow Filter Rig was drained and cleaned. It was filled with DIF water and run to compare the performance of the cleaned filter to the performance obtained during DIF water runs in shakedown prior to operation with Batch #1. The shakedown fluxes were: 0.675 gpm/ft^2 @ 12.5 ft/sec and 23.9 psid, 0.384 gpm/ft^2 @ 20.6 ft/sec and 17.4 psid, and 0.630 gpm/ft^2 @ 20.8 ft/sec and 28.4 psid. The water runs after Batch #1 and cleaning were: 0.396 gpm ft^2 @ 12.5 ft/sec and 23.1 psid, 0.409 gpm/ft^2 @ 20.9 ft/sec and 19.1 psid, and 0.600 gpm/ft^2 @ 20.7 ft/sec and 27.6 psid. There is excellent agreement at the higher velocities, but poorer comparison at the lower velocity.

After completing the Batch #2 filtration, a set of DIF water runs was made after cleaning the filter to compare with the water runs made after cleaning the filter following the Batch #1 experiment. In hindsight the runs were not maintained at constant conditions long enough to obtain definitive fluxes. The available data for two sets of runs at similar conditions before and after Batch #2 are plotted in Figure 3-21 and Figure 3-22. Raw data collected during the DIF water runs is included in Excel format on the report CD-ROM.

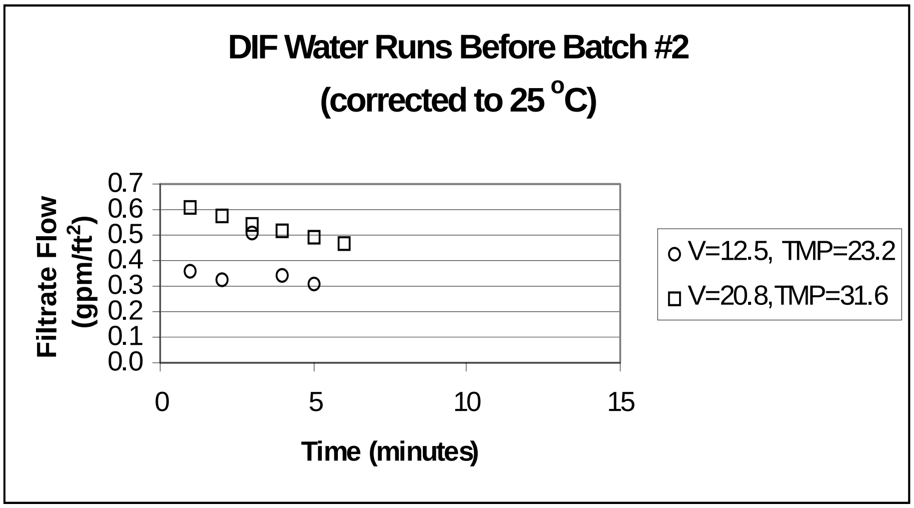

Figure 3-21. Crossflow Filter Flux with Clear Water Prior to Batch #2 Processing

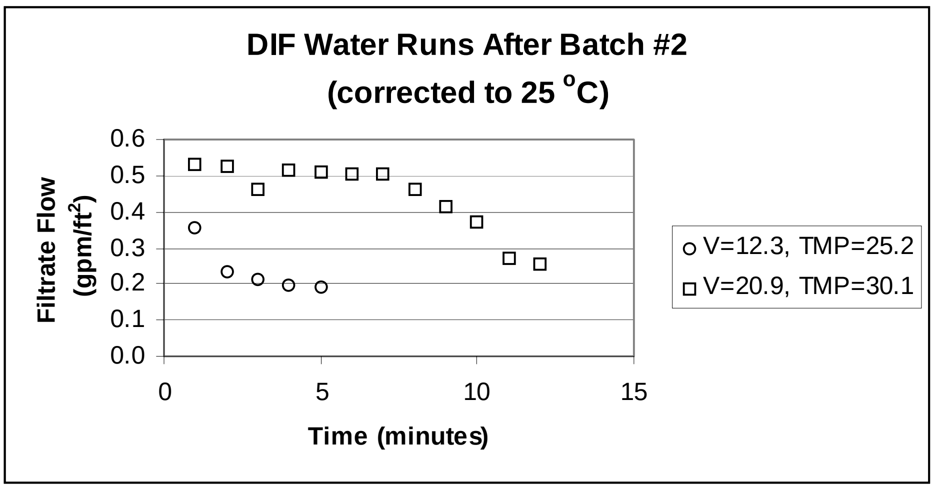

Figure 3-22. Crossflow Filter Flux with Clear Water After Batch #2 Processing

3.9.3 Post Precipitation Solids

Two filtrate samples taken about 8 hours after completion of reagent addition in the Batch #1 experiment were analyzed 18 hours after collection by Lasentec. Even though the samples were visually clear, the analysis indicated the presence of solids with a mean chord length of 6.7 microns measured at a concentration of 3500 counts/sec. Another filtrate sample was taken 47 hours after completion of reagent addition and analyzed 24 hours later. It contained larger particles (75 microns), but at a much lower count rate (55 counts/sec). Subsequent filtration samples taken at 122 hours and 145 hours after the reagent addition had insignificant amounts of solids. Lasentec analysis of all Batch #1 filtration samples was repeated after five months of storage with little change in the relative amounts of solids.

The filtrate collected from slurry precipitated with the Batch #2 process appeared to be more stable. After several months of storage some solids were formed, but there were very little solids formed in filtrate allowed to stand a day or two.

The filtrate from the Batch #3C slurry was collected in a large black plastic tank covered to prevent light exposure. None of the samples from the composite filtrate tank, or samples collected directly from the filtrate line and allowed to sit, showed significant solid formation after several days.

The filtrate from the Batch #3B slurry was also collected in the large black covered tank. A sample collected from the composite filtrate tank 29 hours after reagent addition showed no significant solids. A sample collected 142 hours after reagent addition showed a small amount of solids (154 counts/sec) of about 16 micron chord length.

Due to a lack of storage drums and readily available storage tanks, the filtrate from the Batch #3A slurry was added to the composite filtrate collected from the Batch #3B slurry. However, after every hour, a sample of filtrate proportional to the filtrate flow rate was obtained during dewatering and added to a 5-gallon carboy to generate a small composite sample. (The carboy was stored in a cardboard box to eliminate exposure to light.) The carboy was sampled 169 hours after reagent addition and showed very few solids present. It was sampled again 335 hours after reagent addition. Lasentec analysis showed about 46 counts/sec of 13 micron average chord length particles. The entire 12.6 liters of composite sample was filtered to recover 16 grams of dried solids, or about 1.3 grams of solids per liter of filtrate.

When the tank containing the combined Batch #3B and #3A filtrate was uncovered there was a substantial amount of light yellow solids adhering to the tank walls and bottom. The tank agitator was unable to remove these solids from the surfaces.

The filtrate from the Batch #4A slurry was split into 4 approximately equal streams and put into blue plastic drums. Lasentec analysis was not done on the Batch #4A filtrate. The drums were allowed to stand for 215 hours after reagent addition (about a week after filtration was completed). One of the drums containing 208 kg of filtrate was then carefully decanted down to about 4 liters. The last 4 liters were vacuum-filtered and dried at 105 ^{o}C to recover 648 grams of solids. Since the filtrate density was about 1.28 gm/ml, the solid content was (648 gms)(1.28 gm/ml)/(208 kg) = 4.0 grams of solids per liter of filtrate. Some of the solids were sent off for microtrac particle size analysis. Most of the particles were between 2 and 5 microns with the mean (by number distribution) being 2.64 micron. The detailed microtrac results are shown in Appendix I.

3.9.4 Pulse jet Mixing

As described in 3.4.2, Batch #4A was mixed using pulse jet mixer. There was considerable discussion about what type of pulse should be used to provide representative mixing. The plant design at that time called for pulsing 6% of the tank volume every 77 seconds, using a 19-second duration pressure pulse. Work done by others in a large tank with multiple pulse jets indicated the tank was well mixed when there was visible motion of the surface with a velocity of about 1 ft/sec. Experimentation in the pulse jet mixed pilot precipitation tank showed that surface motion of about 1 ft/sec could be obtained with a pulse of 6% of the tank volume if a 1.6-second pressure pulse duration was used. The total cycle time was set at 77 seconds to match the plant design of 6% pulsed every 77 seconds.

During shakedown with water, we found the pulse jet control system to be quite stable and provide repeatable pulses. However, with slurry we had to continually adjust the controls to maintain the desired pulse as the precipitation reaction progressed. Apparently the properties of the slurry changed enough to affect the pulse significantly. Without careful adjustments we would get blow out of air from the nozzle. Of course, the control problems were aggravated once the feed to the crossflow slurry reservoir was started and the tank level dropped steadily.

Typical cycles before and after reagent addition are shown in Figure 3-23 and Figure 3-24.

The mixing during the reagent addition was better than generally expected. After the strontium nitrate was added the slurry had the typical yellowish color due to the strontium carbonate solids formed. Once the sodium permanganate was added the liquid at the surface became a dark brown/purple. The recycle stream pumped from the bottom of the tank to the top remained the yellow color until about 20 seconds after the first pulse after permanganate addition started. It then quickly turned a reddish-orange color and remained that color until about 20 seconds after the next pulse. Then it turned a dark orange/brown. Within a few more cycles the color of the recycle stream from the tank bottom matched the color at the top where permanganate was being added.

We had a camera looking at the inside of the pulse tube during the precipitation. With such a short duration pulse it was difficult to make detailed observations, but it was clear that a foam or bubble layer formed inside the tube with each cycle and persisted until the next pressure pulse. At each pressure pulse the bubbles appeared to collapse. A digital video of a few pulses is included on the CD-ROM.

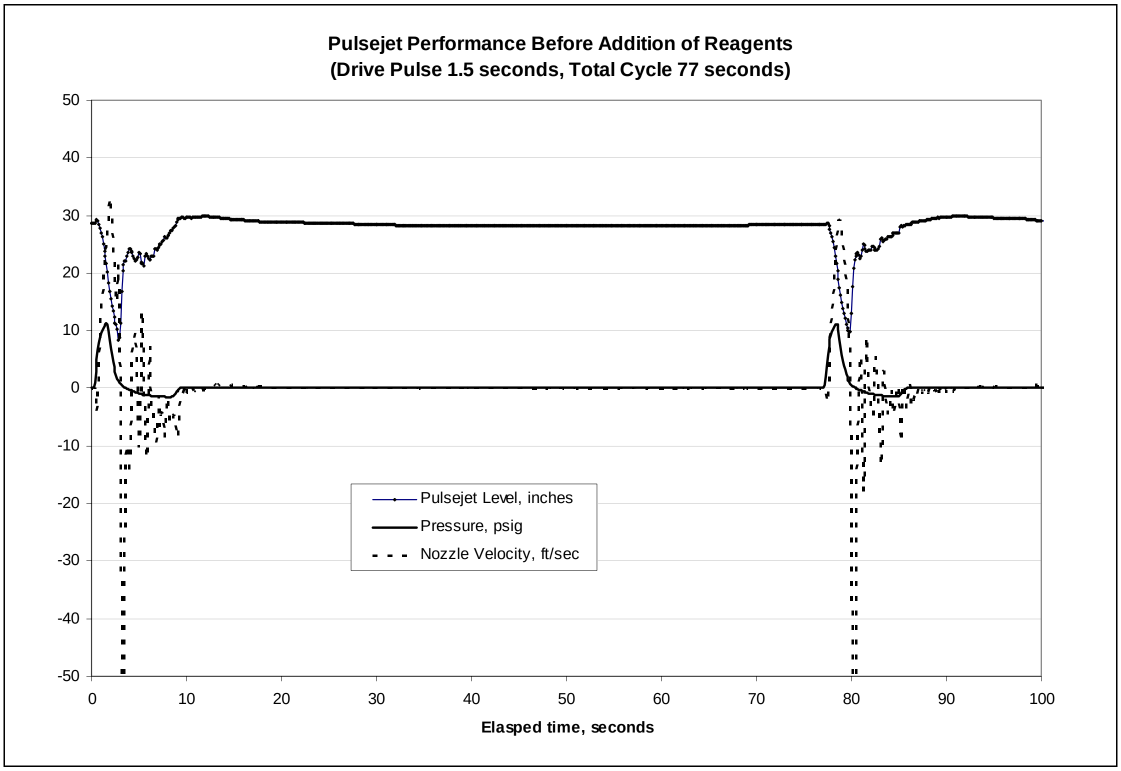

Figure 3-23. Typical Pulse before Reagent Addition

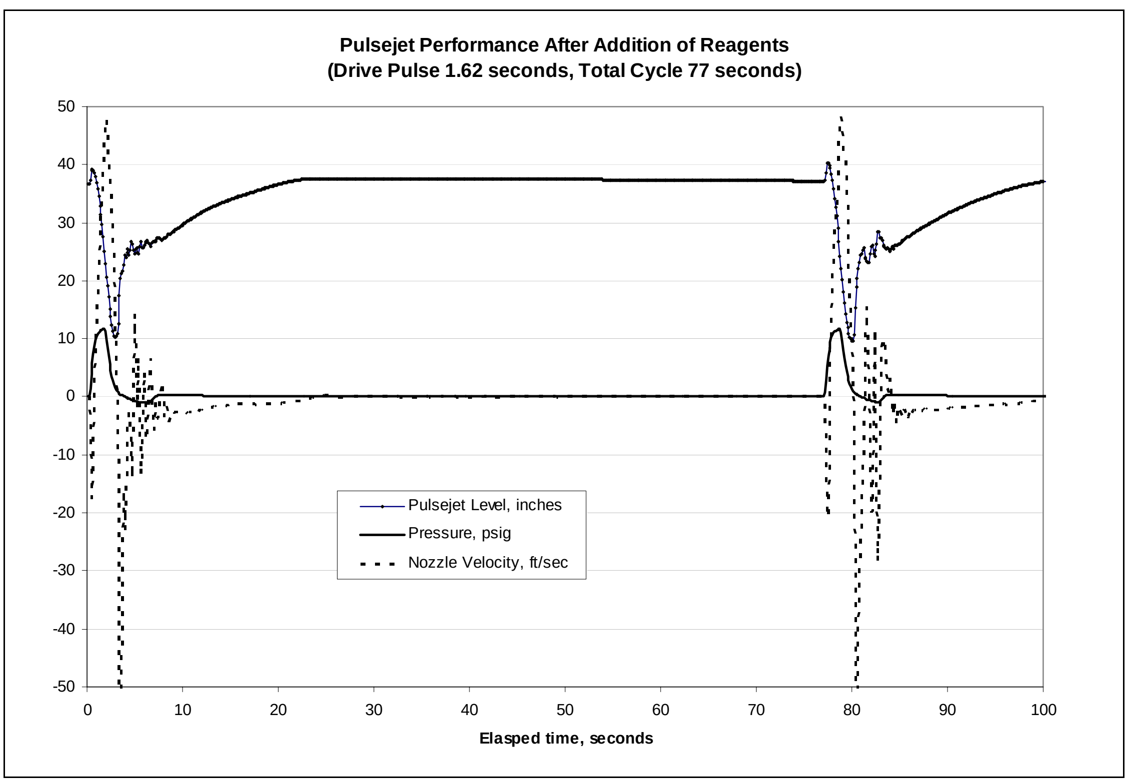

Figure 3-24. Typical Pulse after Reagent Addition

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4.0 FUTURE WORK

It is noted that all pilot-scale precipitations were performed with waste tank simulant feed without recycle streams indicated in the current process flowsheets for WTP. Thus it is recommended that pilot-scale precipitation be performed with recycle streams added to accurately reflect their effect on the precipitation and subsequent filterability of material per the WTP process flowsheet.

Calcium and nitrate are in the HLW SBS Recycle, which is fed with Sr/TRU precipitate to the crossflow filters. Prior testing by SRTC (Rosencrance, 33) has shown that calcium nitrate present in recycle streams increases the TRU DF, but decreases the filter flux. Table 1-2 shows that the filtrate flux is marginal at 0.02 gpm/ft^2 of filter area with Envelope C waste without recycle streams. Table 1-2 also shows that reduced caustic caused by acid recycle streams may also impede filter flux.

The difficulty of the Pilot Pulse Jet Control System to respond to the rapidly changing slurry properties during the precipitation reaction is also noted. Thus, it is recommended that precipitation be performed in a scaled UFP Tank of current design with recycle streams and actual AEA Technology PJM control System. This testing will ensure the ability to provide repeatable pulses throughout the anticipated level changes, changes in slurry properties during precipitation, and subsequent cooldown with transfer to the crossflow filter.

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5.0 REFERENCES

1. Williams, M. R., "Task Technical and Quality Assurance Plan In Support of RPP-WTP Pilot-Scale Precipitation Testing," SRT-RPP-2000-00050, Rev. 0, approved on June 19, 2001.

2. Williams, M. R., Screening Process Review Report, approved on Jan. 3, 2001.

3. Williams, M. R., Environmental Evaluation Checklist, EEC Document No. TC-A-2000-073, Rev. 1, approved on January 23, 2001.

4. Williams, M. R., "RPP Job Folder 22806 Pilot Scale Precipitation Testing," Laboratory Notebook, Document No. WSRC-NB-2001-00078. [Construction, shakedown and Batch 1, 2, 3C, 3B, and 3A test activities are documented.]

5. Steeper, T. J., WSRC Drawing No. EES-22806-M6-001, "RPP-WTP Pilot Scale Precipitation Testing Test Rig Setup," Rev. B, May 5, 2001.

6. Steeper, T. J., WSRC Drawing No. EES-22699-M6-003, "RPP Part B2 Pilot Scale Crossflow Filter Tests Test Rig Assembly with 40" Filter and New Pumps," Rev. A, May 1, 2001.

7. Williams, M. R., "RPP-WTP Pilot Scale Precipitation Testing Procedure," EDS Field Procedure, Document No. FP-882, Rev. 0, Effective September 24, 2001.

8. Williams, M. R., Operational Instructions No. 1-4, starting from No. 1: "Determination of Cleanliness of the Pilot Scale Precipitation System and Crossflow Test Rig per FP-882," October 2, 2001 to No. 4: "Caustic Addition to 1M NaOH of Batch #2 AN-107 simulant in the Pilot Scale Precipitation and additional Filtrate samples," October 15, 2001.

9. Duignan, M. R., "Final Report: Pilot-Scale Cross-flow Ultrafiltration Test Using a Hanford Site Tank 241-AN-105 Waste Simulant – Envelope A + Entrained Solids," BNF-003-98-0221, February 23, 2000.

10. Nash, C. A., Rosencrance, S. W., Walker, B. W., Wilmarth, B. R., "Investigation of Varied Strontium-Transuranic Precipitation Chemistries for Crossflow Filtration," BNF-003-98-0171, Revision 0, April 18, 2000.

11. Nash, C. A., Saito, H. H., Wilmarth, B. R., "Strontium-Transuranic Precipitation and Crossflow Filtration of 241-AN-102 Large C," BNF-003-98-0317, Revision 0, December 5, 2000.

12. Benedict, M., Pigford, T. H., Levi, H. W., "Nuclear Chemical Engineering", Second Edition, McGraw-Hill Book Company, New York, 1981, pp. 407-420.

13. Nash, C. A., Rosencrance, S. W., Wilmarth, B. R., “Entrained Solids, Strontium-Transuranic Precipitation and Crossflow Filtration of 241-AN-102 Large C,” SRT-RPP-2000-00003, Revision 0, August, 2000.

14. Darab, J. G. and Smith, P. A., “Chemistry of Technetium and Rhenium Species during Low-Level Radioactive Waste Vitrification,” Chem. Mater. 1996, 8, 1004-1021, March 5, 1996.

15. Eibling, R. E. and Nash, C. A. “Hanford Waste Simulants Created to Support the Research and Development on the River Protection Project – Waste Treatment Plant,” SRT-RPP-2000-00017, Revision 0, February 2001.

16. Bergmann, L. M. “WTP Material Balance and Process Flowsheet Bases, Requirements, and Results,” 24590-WPT-RPT-ENG-01-004, Rev. 0, October 15, 2001.

17. Duignan, M. R., “Final Report: Pilot-Scale Cross-flow Ultrafiltration Test Using a Hanford Site Tank 241-AN-107 Waste Simulant – Envelope C + Entrained Solids + Strontium-Transuranic Precipitation,” BNF-003-98-0226, Rev. 0, March 24, 2000.

18. Hallen, R. T., Bredt, P. R., Brooks, K. P., and Jagoda, L. K. “Combined Entrained Solids and Sr/TRU Removal from AN-107 Diluted Feed,” BNFL-RPT-027, Rev. 0, August 2000.

19. W. R. Wilmarth, V. H. Dukes, J. T. Mills, F. F. Fondeur, C. C. DiPrete and D. P. DiPrete, "Optimization Study for Strontium and Actinide Removal from 241-AN-107 Supernate," WSRC-TR-2002-00258, September 18, 2002.

20. Williams, Michael R. and Steeper, Timothy J., “Pilot Scale Precipitation Test of AN-107 Simulant Without Caustic Adjustment at 50 ^{o}C,” WSRC-TR-2002-00122, Rev. 0, SRT-RPP-2002-00064, Rev. 0, August 19, 2002.

21. Duignan, M. R., “Final Report: Pilot-Scale Cross-flow Ultrafiltration Test Using a Hanford Site Tank 241-AN-102 Waste Simulant,” WSRC-TR-2003-00202, Rev. 0, SRT-RPP-2003-00087, Rev. 0, May 6, 2003.

22. Hay, M. S., Bronikowski, M. G., Hsu, C. W., White, T. L., “Chemical Characterization of an Envelope C Sample from Hanford Tank 241-AN-102,” USDOE Report BNF-003-98-0250, Rev. 0, Savannah River Site, Aiken, SC 29808 (July 31, 2000).

23. Eibling, R. E. “Development of a Supernate Simulant for Hanford Tank 241-AN-102 Waste,” WSRC-TR-2002-00040, Rev. 0, Draft B, SRT-RPP-2002-00012, Rev. 0, Draft B, May 1, 2002.

24. Williams, Michael R. and Steeper, Timothy J., “Pilot Scale Precipitation Test of AN-107 Simulant with Caustic Adjustment at 20 ^{o}C,” WSRC-TR-2002-00459, Rev. 0, SRT-RPP-2002-00221, Rev. 0, October 31, 2002.

25. Williams, M. R., “Task Technical and Quality Assurance Plan In Support of RPP-WTP Pilot-Scale Precipitation Testing,” SRT-RPP-2000-00050, Rev. 1, approved on November 30, 2001.

26. Williams, M. R., “Task Technical and Quality Assurance Plan In Support of RPP-WTP Pilot-Scale Precipitation Testing,” SRT-RPP-2000-00050, Rev. 2, approved on January 17, 2003.

27. Abodishish, Hani, Test Exception Number: 24590-WTP-TEF-RT-02-060, 8/27/02

28. Abodishish, Hani, Test Exception Number: 24590-WTP-TEF-RT-02-076, 10/4/02

29. Townson, Paul, Test Exception Number: 24590-WTP-TEF-RT-03-027, 5/27/03

30. Williams, M. R., “RPP Job Folder 22806 Pilot Scale Precipitation Testing,” Laboratory Notebook, Document No. WSRC-NB-2003-00026. [Shakedown of PJM Tank, Batch 4A test activities and Post Testing Instrument Calibration are documented.]

31. Williams, M. R., “RPP-WTP Pilot Scale Precipitation Testing Procedure”, EDS Field Procedure, Document No. FP-882, Rev. 1, Effective September 30, 2002.

32. Williams, M. R., “WTP Pilot Scale Precipitation Mixing Procedure,” EDS Field Procedure, Document No. FP-934, Rev. 0, Effective August 30, 2002.

33. Rosencrance, Scott, “Sr and TRU Precipitation Results for 241-AN-102,” BNF-003-98-0161, Savannah River Technology Center, Aiken, South Carolina.

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APPENDICES A – K

APPENDIX A

AN-107 Simulant Formulations

Excess EDTA in simulant

The calculations used in the formulation sheet submitted to the vendor for preparation of the AN-107 supernatant simulant presumed use of disodium ethylenediaminetetraacetic (EDTA) acid dihydrate, but the chemical formula specified on the sheet did not include the two waters of hydration. The compound in question is only available as the dihydrate. The vendor made the appropriate adjustment to use the dihydrate material based upon the specified chemical formula and hence the shipped material appeared to meet the requested recipe, but it actually contained 12% additional EDTA. The error was an internal one made when the simulant recipe sheet was prepared, it should have included the two waters of hydration in the reagent formula because this is what was used in the calculations and included in the approved recipe.

The vendor was given a recipe to follow that included the mass and order of addition of each reagent in the simulant recipe, including the chemical formula of the reagent to use. It did not include the molecular weights of the reagents used in the calculations.

The simulant received was not analyzed because it represented only a portion of the final recipe. The remaining reagents and entrained solids were added to the simulant in the precipitate reactor prior to the start of the pilot run. Following completion of the additions, a final simulant sample was taken and submitted for analysis. Since the EDTA method is one of the more difficult analyses, it was not received for some time following the pilot experiments. This analysis is only good to ± 10%, thus the preparation error was within the combined experimental and reagent purity uncertainty ($Na_2EDTA\cdot 2H_2O$ is not a primary standard material) and would not have been detected had the measurement been received prior to the start of precipitation.

The increased level of EDTA would result in greater Sr solubility in the simulant and potentially a lower decontamination factor. Since the EDTA measurements in the actual waste samples used to prepare the simulant recipe differ by ±20%(one standard deviation), the uncertainty in what the actual value should be exceeds the discrepancy found in the simulant preparation. The experimentally calculated Sr DF exceeds the process requirements, so the impact appears to be negligible.

Simulant Formation Details

The AN107 simulant for Batch 1 and 2 is similar before reagent addition for each Batch processed. The actual material used and entrained solids is different due to slight variation in Batch sizes. The formulation of each Batch using AN-107 simulant is provided in the spreadsheets that follow.

AN-107 Supernate Simulant (based on AN-107; Sr/Tru C-5.5M recipe)

Vessel 1			Recipe amounts for 1300 liters					Actual amounts added by Optima							Notes
			Compound	Water	Non-water			Compound	Water	Non-water				Na	
Compounds	Formula	Formula Weight	mass, grams	mass, grams	mass, grams	Conc., mg/mL	Conc., Molar	mass, grams	mass, grams	mass, grams	Conc., mg/mL	Conc., Molar	% Extra	content, grams	
Water charged to tank			260000.00	260000.00				250927.32	250927.32						
Calcium Nitrate	$Ca(NO_3)_2.4H_2O$	236.15	2838.93	865.56	1973.36	1.518	0.00925	2839.49	865.73	1973.75	1.540	0.00938	1.4		
Cerium Nitrate	$Ce(NO_3)_3.6H_2O$	434.22	133.40	33.18	100.22	0.077	0.00024	133.40	33.18	100.22	0.078	0.00024	1.4		
Cesium Nitrate	$CsNO_3$	194.91	22.25		22.25	0.017	0.00009	22.20		22.20	0.017	0.00009	1.2		
Copper Nitrate	$Cu(NO_3)_2.3H_2O$	241.6	93.30	20.85	72.45	0.056	0.00030	93.30	20.85	72.45	0.057	0.00030	1.4		
Ferric Nitrate	$Fe(NO_3)_3.9H_2O$	403.99	9967.23	3996.86	5970.37	4.593	0.01898	9965.43	3996.14	5969.29	4.656	0.01924	1.4		
Lanthanum Nitrate	$La(NO_3)_3.6H_2O$	433.01	115.64	28.84	86.80	0.067	0.00021	115.60	28.83	86.77	0.068	0.00021	1.4		
Lead nitrate	$Pb(NO_3)_2$	331.2	505.64		505.64	0.389	0.00117	505.60		505.60	0.394	0.00119	1.4		
Magnesium Nitrate	$Mg(NO_3)_2.6H_2O$	256.41	215.02	90.57	124.45	0.096	0.00065	215.00	90.56	124.44	0.097	0.00065	1.4		
Manganous Chloride	$MnCl_2.4H_2O$	197.9	1653.44	601.55	1051.89	0.809	0.00643	1653.00	601.39	1051.61	0.820	0.00652	1.4		
Neodymium Nitrate	$Nd(NO_3)_3.6H_2O$	438.34	237.60	58.54	179.06	0.138	0.00042	237.60	58.54	179.06	0.140	0.00042	1.4		
Nickel Nitrate	$Ni(NO_3)_2.6H_2O$	290.81	2141.06	795.14	1345.92	1.035	0.00566	2141.00	795.12	1345.88	1.050	0.00574	1.4		
Potassium Nitrate	KNO_3	101.11	3754.22		3754.22	2.888	0.02856	3755.75		3755.75	2.930	0.02897	1.4		
Strontium Nitrate	$Sr(NO_3)_2$	211.63	13.01		13.01	0.010	0.00005	13.00		13.00	0.010	0.00005	1.3		
Zinc Nitrate	$Zn(NO_3)_2.6H_2O$	297.47	168.04	61.01	107.03	0.082	0.00043	168.00	60.99	107.01	0.083	0.00044	1.4		
Zirconyl Nitrate	$ZrO(NO_3)_2.XH_2O$	249.23	155.92	11.27	144.65	0.111	0.00048	155.90	11.27	144.63	0.113	0.00049	1.4		
EDTA	Na_2EDTA	372.24	5917.79	572.32	5345.47	4.112	0.01223	6536.27	632.13	5904.13	4.605	0.01370	12.0	807	(1)
HEDTA	HEDTA	278.26	1763.87		1763.87	1.357	0.00488	1764.00		1764.00	1.376	0.00494	1.4		
Sodium Gluconate	$CH_2OH(CHOH)_4COONa$	218.14	3201.21		3201.21	2.462	0.01129	3202.36		3202.36	2.498	0.01145	1.4	338	
Glycolic Acid	$HOCH_2COOH$	76.05	21954.11		21954.11	16.888	0.22206	31361.38	9408.41	21952.96	17.124	0.22516	1.4		(2)
Citric Acid	$HOC(CH_2CO_2H)_2CO_2H$	192.13	7696.54		7696.54	5.920	0.03081	7697.92		7697.92	6.004	0.03125	1.4		
Nitrilotriacetic Acid	$N(CH_2COOH)_3$	191.14	464.72		464.72	0.357	0.00187	464.70		464.70	0.362	0.00190	1.4		
Iminodiacetic Acid	$HN(CH_2CO_2H)_2$	133.1	4923.03		4923.03	3.787	0.02845	4921.48		4921.48	3.839	0.02884	1.4		
Boric acid	H_3BO_3	61.83	163.21		163.21	0.126	0.00203	163.20		163.20	0.127	0.00206	1.4		
Sodium Chloride	NaCl	58.44	1482.80		1482.80	1.141	0.01952	1483.00		1483.00	1.157	0.01979	1.4	583	
Sodium Fluoride	NaF	41.99	239.66		239.66	0.184	0.00439	239.70		239.70	0.187	0.00445	1.4	131	
Sodium Chromate	Na_2CrO_4	161.97	446.98		446.98	0.344	0.00212	447.00		447.00	0.349	0.00215	1.4	127	
Sodium Sulfate	Na_2SO_4	142.04	9945.79		9945.79	7.651	0.05386	9947.28		9947.28	7.759	0.05463	1.4	3220	
Potassium Molybdate	K_2MoO_4	238.14	72.45		72.45	0.056	0.00023	72.50		72.50	0.057	0.00024	1.5		
Total Weights in vessel 1			340286.84	267135.70	73151.15			341242.36	267530.47	73711.89				5206	

Notes (1) The formula in the recipe sent to Optima showed anhydrous EDTA, Na_2EDTA. Optima added the dihydride, so calculated they needed 14.44 lbs of the dihydride to get 14.41*453.59*[336.24/(336.24+2*18)] = 5917 g of anhydrous Na_2EDTA. They also decreased the amount of water they used by 14.41*453.59*(2*18)/(336.24+2*18) = 633 g. Unknown to Optima, the recipe was based on adding 5917 g of the dihydride, so Optima's adjustments actually caused the addition of too much EDTA.

(2) Optima substituted 70 w% Glycolic Acid for the Anhydrous Glycolic Acid shown in the recipe.

AN-107 Supernate Simulant (based on AN-107; Sr/Tru C-5.5M recipe)

Vessel 2 (added to contents of vessel 1 after mixing)			Recipe amounts for 1300 liters					Actual amounts added by Optima							Notes
			Compound	Water	Non-water			Compound	Water	Non-water				Na	
Compounds	Formula	Formula Weight	mass, grams	mass, grams	mass, grams	Conc., mg/mL	Conc., Molar	mass, grams	mass, grams	mass, grams	Conc., mg/mL	Conc., Molar	% Extra	content, grams	
Water charged to tank			260000.00	260000.00				163610.78	163610.78						
Sodium Hydroxide	NaOH	40	20596.52		20596.52	15.843	0.39609	41617.10	20808.55	20808.55	16.231	0.40577	2.4	11960	(3)
Aluminum Nitrate	$Al(NO_3)_3.9H_2O$	375.13	4375.31	1889.48	2485.83	1.912	0.00897	7293.77	4806.59	2487.17	1.940	0.00910	1.5		(6)
Sodium Phosphate	$Na_3PO_4.12H_2O$	380.12	3622.08	2058.22	1563.86	1.203	0.00733	1560.36		1560.36	1.217	0.00742	1.2	656	(4)
Sodium Formate	NaHCOO	68.01	12809.40		12809.40	9.853	0.14488	12809.45		12809.45	9.992	0.14691	1.4	4330	
Sodium Acetate	$NaCH_3COO.3H_2O$	136.08	1931.56	766.49	1165.07	0.896	0.01092	1165.73		1165.73	0.909	0.01108	1.5	327	(5)
Sodium Oxalate	$Na_2C_2O_4$	134	1025.21		1025.21	0.789	0.00589	1025.12		1025.12	0.800	0.00597	1.4	352	
Sodium Carbonate	Na_2CO_3	105.99	120865.25		120865.25	92.973	0.87719	120882.37		120882.37	94.290	0.88961	1.4	52441	
Water used to clean vessel 2 & flush hose								75296.34	75296.34						
Total added from vessel 2			425225.33	264714.19	160511.14			425261.02	264522.26	160738.76				70064	
Vessel 3 (added to combined vessel 1 and 2 after mixing)			Recipe amounts for 1300 liters					Actual amounts added by Optima							Notes
			Compound	Water	Non-water			Compound	Water	Non-water				Na	
Compounds	Formula	Formula Weight	mass, grams	mass, grams	mass, grams	Conc., mg/mL	Conc., Molar	mass, grams	mass, grams	mass, grams	Conc., mg/mL	Conc., Molar	% Extra	content, grams	
Water charged to tank			130000.00	130000.00				478539.98	478539.98						
Sodium Nitrate	$NaNO_3$	84.99	242371.35		242371.35	186.440	2.19366	242354.42		242354.42	189.040	2.22426	1.4	65557	
Sodium Nitrite	$NaNO_2$	69	74589.14		74589.14	57.376	0.83154	74570.59		74570.59	58.166	0.84299	1.4	24846	
Water used to clean vessel 3 & flush hose								37648.17	37648.17						
Water added at end to bring volume up to total			404364.00	404364.00					0.00						(7)
Total added to previous mixture			851324.49	534364.00	316960.49			833113.16	516188.15	316925.01				90404	
Overall totals			1616836.66	1066213.88	550622.78			1599616.54	1048240.88	551375.66				165674	
Volume, ml			1300000.00					1282027.00							(8)
Calculated density, gm/ml			1.2437					1.2477							

Notes: (3) Optima substituted 50 w% Sodium Hydroxide for the Anhydrous Sodium Hydroxide shown in the recipe.

(4) Optima substituted Anhydrous Sodium Phosphate for the hydrated Sodium Phosphate shown in the recipe.

(5) Optima substituted Anhydrous Sodium Acetate for the hydrated Sodium Acetate shown in the recipe.

(6) The aluminum nitrate was added as a 60 w% of $Al(NO_3)_3.9H_2O$ in water, or a 34.1 w% solution of alumina nitrate. Optima added 7294*0.341 = 2487 grams of aluminum nitrate and 7294*0.659 = 4807 grams of water.

(7) One of the last steps in the Optima procedure called for flushing out the tank and hoses with 40 lb of water and loading it into a drum. This drum was not delivered to SRS, making the simulant 40*453.95 = 18158 g short of water. This caused the concentrations to be about 1.4% high.

(8) Optima volume was estimated by substracting 1 ml per gram of water not added to the supernate.

Complete Batch #1 AN-107 Simulant before reagent addition

Entrained Solids and Perrhenate added in EDL (1)			Recipe amounts for 650 liters					Actual amounts for Batch 1 simulant							Notes
			Compound	Water	Non-water			Compound	Water	Non-water					
Compounds	Formula	Formula Weight	mass, grams	mass, grams	mass, grams	(3) Conc., mg/mL	(3) Conc., Molar	mass, grams	mass, grams	mass, grams	(4) Conc., mg/mL	(4) Conc., Molar	(5) % Extra	Na content, grams	
Sodium Perrhenate	$NaReO_4$	273.2	11.16		11.16	0.017	0.00006	11.16		11.16	0.017	0.00006	0.4	1	
Aluminum Oxide	Al_2O_3	101.96	225.30		225.30	0.347	0.00340	225.3		225.30	0.348	0.00341	0.4		(2)
Calcium Phosphate	$Ca_3(PO_4)_2$	310.18	2.93		2.93	0.005	0.00001	2.93		2.93	0.005	0.00001	0.4		
Chromic Oxide	Cr_2O_3	151.99	15.47		15.47	0.024	0.00016	15.47		15.47	0.024	0.00016	0.4		
Ferric Oxide	Fe_2O_3	159.69	192.75		192.75	0.297	0.00186	192.8		192.80	0.298	0.00186	0.4		
Manganese Dioxide	MnO_2	86.94	124.78		124.78	0.192	0.00221	124.7		124.70	0.193	0.00222	0.3		
Silicon Dioxide	SiO_2	60.09	21.10		21.10	0.032	0.00054	21.1		21.10	0.033	0.00054	0.4		(2)
Sodium Oxalate	$Na_2C_2O_4$	134	1381.39		1381.39	2.125	0.01586	1381.4		1381.40	2.133	0.01592	0.4	474	
Sodium Carbonate	$Na_2CO_3.H_2O$	124.01	1306.38	189.62	1116.76	1.718	0.01621	1306.4	189.62	1116.78	1.725	0.01627	0.4	484	
Sodium Fluoride	NaF	41.99	202.10		202.10	0.311	0.00740	202.1		202.10	0.312	0.00743	0.4	111	
Sodium Sulfate	$Na_2SO_4.10H_2O$	322.2	166.97	93.28	73.69	0.113	0.00080	167	93.30	73.70	0.114	0.00080	0.4	24	
Sodium Phosphate	$Na_3PO_4.12H_2O$	380.12	373.97	212.51	161.46	0.248	0.00151	374	212.52	161.48	0.249	0.00152	0.4	68	
Mass of compounds added to supernate simulant			4024.30	495.41	3528.89			4024.36	495.44	3528.92				1162	
Mass of supernate simulant used per batch, grams			808418					807950						84842	
Calculated volume of supernate simulant (based on mass used and calculated density), ml			650000					647539							
Sodium molarity of supernate simulant														5.70	
grams			812443					811974						86004	
Calculated density of final simulant (neglecting small volume increase due to adding solids), gm/ml			1.2499					1.2539							

Notes: (1) All solids added were less than or equal to 5 microns in size

(2) The recipe specified 0.1754 moles of sodium aluminosilicate, $Na_2.Al_2O_3.(SiO_2)_2.5H_2O$ that was unavailable from suppliers. The author of the recipe was contacted and recommended the substitution of 2*0.1754 = 0.3058 moles = 21.08 grams of SiO2 and 0.1754 moles = 17.88 grams of Al_2O_3 instead. The 17.88 grams of Al_2O_3 was added to the 207.38 grams Al_2O_3 in the original entrained solids recipe for a total of 225.26 grams Al_2O_3 to be added.

(3) An error was made when the recipe concentrations were reported in the previous interim reports. The concentrations had been calculated using the double batch size of 1300 liters rather than the half batch size of 650 liters.

(4) An error was made when the actual concentrations were previously reported in the Batch 1 interim report. The concentrations had been calculated using the double batch size of 1282 liters rather than the approximately half batch size of 648 liters actually used in Batch 1.

(5) Solids were weighed out and added based on a 650 liter batch. The simulant was added to the tank by weight, not volume. The actual volume was slightly less than expected when the solids were added resulting in a small excess of solids.

Complete Batch #2 AN-107 Simulant before reagent addition

Entrained Solids and Perrhenate added in EDL (1)			Recipe amounts for 650 liters					Actual amounts for Batch 2 simulant							Notes
			Compound	Water	Non-water			Compound	Water	Non-water					
Compounds	Formula	Formula Weight	mass, grams	mass, grams	mass, grams	(3) Conc., mg/mL	(3) Conc., Molar	mass, grams	mass, grams	mass, grams	(4) Conc., mg/mL	(4) Conc., Molar	(5) % Extra	Na content, grams	
Sodium Perrhenate	$NaReO_4$	273.2	11.16		11.16	0.017	0.00006	11.16		11.16	0.018	0.00006	2.4	1	
Aluminum Oxide	Al_2O_3	101.96	225.30		225.30	0.347	0.00340	225.2		225.20	0.355	0.00348	2.4		(2)
Calcium Phosphate	$Ca_3(PO_4)_2$	310.18	2.93		2.93	0.005	0.00001	2.93		2.93	0.005	0.00001	2.4		
Chromic Oxide	Cr_2O_3	151.99	15.47		15.47	0.024	0.00016	15.47		15.47	0.024	0.00016	2.4		
Ferric Oxide	Fe_2O_3	159.69	192.75		192.75	0.297	0.00186	192.7		192.70	0.304	0.00190	2.4		
Manganese Dioxide	MnO_2	86.94	124.78		124.78	0.192	0.00221	124.6		124.60	0.196	0.00226	2.3		
Silicon Dioxide	SiO_2	60.09	21.10		21.10	0.032	0.00054	21.09		21.09	0.033	0.00055	2.4		(2)
Sodium Oxalate	$Na_2C_2O_4$	134	1381.39		1381.39	2.125	0.01586	1381.4		1381.40	2.177	0.01625	2.4	474	
Sodium Carbonate	$Na_2CO_3.H_2O$	124.01	1306.38	189.62	1116.76	1.718	0.01621	1306.4	189.62	1116.78	1.760	0.01660	2.4	484	
Sodium Fluoride	NaF	41.99	202.10		202.10	0.311	0.00740	202.1		202.10	0.319	0.00759	2.4	111	
Sodium Sulfate	$Na_2SO_4.10H_2O$	322.2	166.97	93.28	73.69	0.113	0.00080	167	93.30	73.70	0.116	0.00082	2.5	24	
Sodium Phosphate	$Na_3PO_4.12H_2O$	380.12	373.97	212.51	161.46	0.248	0.00151	374	212.52	161.48	0.255	0.00155	2.5	68	
Mass of compounds added to supernate simulant			4024.30	495.41	3528.89			4024.05	495.44	3528.61				1162	
Mass of supernate simulant used in Batch #2, grams			808418					791667						83156	
Calculated volume of supernate simulant (based on mass used and calculated density), ml			650000					634488							
Sodium molarity of supernate simulant														5.70	
Total mass of supernate simulant and EDL additions, grams			812443					795691						84317	
Calculated density of final simulant (neglecting small volume increase due to adding solids), gm/ml			1.2499					1.2541							

Notes: (1) All solids added were less than or equal to 5 microns in size

(2) The recipe specified 0.1754 moles of sodium aluminosilicate, $Na_2.Al_2O_3.(SiO_2)_2.5H_2O$ that was unavailable from suppliers. The author of the recipe was contacted and recommended the substitution of 2*0.1754 = 0.3058 moles = 21.08 grams of SiO2 and 0.1754 moles = 17.88 grams of Al_2O_3 instead. The 17.88 grams of Al_2O_3 was added to the 207.38 grams Al_2O_3 in the original entrained solids recipe for a total of 225.26 grams Al_2O_3 to be added.

(3) An error was made when the recipe concentrations were previously reported in the Batch 2 interim report. The concentrations had been calculated using the double batch size of 1300 liters rather than the half batch size of 650 liters.

(4) An error was made when the actual concentrations were previously reported in the Batch 2 interim report. The concentrations had been calculated using the double batch size of 1282 liters rather than the approximately half batch size of 634 liters actually used in Batch 2.

(5) Solids were weighed out and added based on a 650 liter batch. The simulant was added to the tank by weight, not volume. The actual volume was slightly less than expected when the solids were added resulting in a small excess of solids.

APPENDIX B

AN-102R2 Simulant Formulations

The AN102 simulant for Batch 3C, 3B, 3A and 4A is the same before remediation for each Batch processed. The remediation and addition of entrained solids is different due to varying Batch sizes. The formulation of each Batch using AN-102R2 simulant is provided in the spreadsheets that follow.

Purchased simulant formulation:

AN-102 Simulant before remediation (AN-102 with Sulfate; 6.5 M Na recipe)											
Mixed in Vessel 1			Recipe amounts for 4700 liters			Actual amounts added by Optima					Notes
			Compound	Water	Non-water	Compound	Water	Non-water			
Compounds	Formula	Formula Weight	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	% Extra	Na content, grams	
Water charged to tank			940000.00	940000.00		2172163.29	2172163.29				
Calcium Nitrate	$Ca(NO_3)_2.4H_2O$	236.15	8685.65	2648.18	6037.47	8663.61	2641.46	6022.16	-0.3		
Cesium Nitrate	$CsNO_3$	194.91	128.25		128.25	128.30		128.30	0.0		
Copper Nitrate	$Cu(NO_3)_2.2.5H_2O$	241.60	267.11	49.75	217.36	267.10	49.75	217.35	0.0		
Ferric Nitrate	$Fe(NO_3)_3.9H_2O$	403.99	760.21	304.84	455.37	760.20	304.84	455.36	0.0		
Lanthanum Nitrate	$La(NO_3)_3.6H_2O$	433.01	127.40	31.78	95.62	127.40	31.78	95.62	0.0		
Lead nitrate	$Pb(NO_3)_2$	331.20	872.56		872.56	872.60		872.60	0.0		
Manganous Chloride	$MnCl_2.4H_2O$	197.90	189.28	68.86	120.42	189.30	68.87	120.43	0.0		
Nickel Nitrate	$Ni(NO_3)_2.6H_2O$	290.81	6074.99	2256.11	3818.88	6078.14	2257.28	3820.86	0.1		
Potassium Nitrate	KNO_3	101.11	16545.01		16545.01	16556.12		16556.12	0.1		
Strontium Nitrate	$Sr(NO_3)_2$	211.63	75.00		75.00	75.00		75.00	0.0		
Zinc Nitrate	$Zn(NO_3)_2.6H_2O$	297.47	75.70	27.48	48.22	75.71	27.49	48.22	0.0		
Zirconyl Nitrate	$ZrO(NO_3)_2.H_2O$	249.23	135.58	9.79	125.79	135.60	9.79	125.81	0.0		
EDTA	$Na_2C_{10}H_{14}N_2O_8.2H_2O$	372.24	11337.07	1096.43	10240.64	11339.81	1096.69	10243.12	0.0	1401	
HEDTA	$Na_3C_{10}H_{15}N_2O_7$	344.21	730.13		730.13	1750.87	1033.01	717.86	-1.7	144	(1)
Sodium Gluconate	$CH_2OH(CHOH)_4COONa$	218.14	3172.50		3172.50	3172.43		3172.43	0.0	334	
Citric Acid	$HOC(CH_2CO_2H)_2CO_2H$	192.13	2043.70		2043.70	2043.89		2043.89	0.0		
Nitrilotriacetic Acid	$N(CH_2COOH)_3$	191.14	759.30		759.30	759.31		759.31	0.0		
Iminodiacetic Acid	$HN(CH_2CO_2H)_2$	133.10	13456.58		13456.58	13471.69		13471.69	0.1		
Succinic Acid	$C_4H_6O_4$	118.04	106.91		106.91	106.90		106.90	0.0		
Boric acid	H_3BO_3	61.83	684.55		684.55	684.47		684.47	0.0		
Sodium Chloride	$NaCl$	58.44	18702.37		18702.37	18688.01		18688.01	-0.1	7352	
Sodium Fluoride	NaF	41.99	14516.51		14516.51	14514.96		14514.96	0.0	7947	
Sodium Sulfate	Na_2SO_4	142.04	57322.85		57322.85	57334.08		57334.08	0.0	18560	
Potassium Molybdate	K_2MoO_4	238.14	427.50		427.50	427.50		427.50	0.0		
Total Weights in vessel 1			1097196.71	946493.22	150703.48	2330386.28	2179684.24	150702.04		35737	
Notes (1)	Optima substituted 41 w% solution of Trisodium HEDTA instead of anhydrous Trisodium HEDTA.										

AN-102 Simulant before remediation (AN-102 with Sulfate; 6.5 M Na recipe)											Notes
Vessel 2 (added to vessel 1 after mixing)			Recipe amounts for 4700 liters			Actual amounts added by Optima					
			Compound	Water	Non-water	Compound	Water	Non-water			
Compounds	Formula	Formula Weight	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	% Extra	Na content, grams	
Water charged to tank			940000.00	940000.00		93077.16	93077.16				
Sodium Hydroxide	NaOH	40.00	429364.44		429364.44	858196.82	429098.41	429098.41	-0.1	246624	(2)
Aluminum Nitrate	$Al(NO_3)_3.9H_2O$	375.13	609992.97	263425.64	346567.33	1016682.01	669993.44	346688.56	0.0		(3)
Sodium Phosphate	$Na_3PO_4.12H_2O$	380.12	59726.86	33939.29	25787.57	25764.05		25764.05	-0.1	10827	(4)
Sodium Formate	NaHCOO	68.01	35280.10		35280.10	35289.49		35289.49	0.0	11929	
Sodium Glycolate	$HOCH_2COONa$	98.01	41946.69	0.00	41946.69	41957.30		41957.30	0.0	9842	
Sodium Acetate	$NaCH_3COO.3H_2O$	136.08	5052.48	2004.95	3047.53	5034.88		5034.88	65.2	1410	(5)
Sodium Oxalate	$Na_2C_2O_4$	134.00	2266.45		2266.45	2266.60		2266.60	0.0	778	
Water used to clean tank & flush lines						45359.24	45359.24				
Sodium Chromate	Na_2CrO_4	161.97	2355.13		2355.13	2355.05		2355.05	0.0	669	
Sodium Carbonate	Na_2CO_3	105.99	386906.87		386906.87	386914.32		386914.32	0.0	167849	
Total Weights added from vessel 2			2512891.99	1239369.88	1273522.11	2512896.91	1237528.25	1275368.65		449928	
Vessel 3 (added to combined vessel 1 and 2 after mixing)			Recipe amounts for 4700 liters			Actual amounts added by Optima					Notes
			Compound	Water	Non-water	Compound	Water	Non-water			
Compounds	Formula	Formula Weight	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	% Extra	Na content, grams	
Water charged to tank			470000.00	470000.00		470012.44	470012.44				
Sodium Nitrate	$NaNO_3$	84.99	351127.68		351127.68	351125.88		351125.88	0.0	94980	
Sodium Nitrite	$NaNO_2$	69.00	370763.19		370763.19	370766.43		370766.43	0.0	123535	
Water used to clean vessel 3 and flush hose						27215.54	27215.54				
Water used to clean vessel 1 and flush hose after loading drums						0.00	0.00				(6)
Water added at end to bring volume up to total			1277493.77	1277493.77							
Total Weights added to previous mixture			2469384.64	1747493.77	721890.87	1219120.29	497227.99	721892.30		218515	
Overall totals			6079473.34	3933356.88	2146116.46	6062403.48	3914440.48	2147963.00		704181	
Volume, ml			4700000.00			4681083.61					(7)
Calculated density, gm/ml			1.2935			1.2951					

(2) Optima substituted 50 wt% Sodium Hydroxide for the Anhydrous Sodium Hydroxide shown in the recipe.

(3) The Aluminum Nitrate was added as a 60 w% of $Al(NO_3)_3.9H_2O$ in water, or a 34.1 w% solution of Aluminum Nitrate. Optima added 1016682*0.341 = 346689 grams of Aluminum Nitrate and 1016682*0.659 = 669993 grams of water.

(4) Optima substituted anhydrous Sodium Phosphate for the hydrated Sodium Phosphate shown in the recipe.

(5) Optima substituted anhydrous Sodium Acetate for the hydrated Sodium Acetate shown in the recipe.

(6) One of the last steps in the Optima procedure called for flushing out vessel 1 and hoses with 40 lb of water and loading it into a final drum. This drum was not shipped to SRTC.

(7) Optima volume was estimated by substracting 1 ml per gram of water not added to the supernate.

Batch #3C simulant remediation and entrained solids:

Batch #3C Simulant Remediation											
			Recipe amounts for 812 liters			Actual amounts added by EDL					Notes
			Compound	Water	Non-water	Compound	Water	Non-water			
Compounds	Formula	Formula Weight	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	% Extra	Na content, grams	
Water charged to tank			283241.14	283241.14		283300.00	283300.00				
Aluminum Nitrate	$Al(NO_3)_3.9H_2O$	375.13	59274.31	25597.63	33676.68	59300.00	25608.72	33691.28	0.0		
Cadmium Nitrate	$Cd(NO_3)_2.4H_2O$	308.48	110.83	25.87	84.96	110.70	25.84	84.86	-0.1		
Calcium Nitrate	$Ca(NO_3)_2.4H_2O$	236.15	1149.42	350.45	798.97	1149.40	350.44	798.96	0.0		
Cerium Nitrate	$Ce(NO_3)_3.6H_2O$	434.22	91.76	22.82	68.94	91.70	22.81	68.89	-0.1		
Cesium Nitrate	$CsNO_3$	194.91	4.13		4.13	4.12		4.12	-0.3		
Cobalt Nitrate	$Co(NO_3)_3.6H_2O$	353.03	10.93	3.34	7.59	10.90	3.33	7.57	-0.3		
Copper Nitrate	$Cu(NO_3)_2.2.5H_2O$	241.60	35.23	6.56	28.67	35.30	6.57	28.73	0.2		
Ferric Nitrate	$Fe(NO_3)_3.9H_2O$	403.99	133.24	53.43	79.81	133.20	53.41	79.79	0.0		
Lanthanum Nitrate	$La(NO_3)_3.6H_2O$	433.01	68.31	17.04	51.27	68.30	17.04	51.26	0.0		
Lead nitrate	$Pb(NO_3)_2$	331.20	119.57		119.57	119.70		119.70	0.1		
Manganous Chloride	$MnCl_2.4H_2O$	197.90	53.10	19.32	33.78	53.10	19.32	33.78	0.0		
Neodymium Nitrate	$Nd(NO_3)_2.6H_2O$	376.36	163.46	46.91	116.55	163.50	46.92	116.58	0.0		
Nickel Nitrate	$Ni(NO_3)_2.6H_2O$	290.81	833.55	309.56	523.99	833.60	309.58	524.02	0.0		
Potassium Nitrate	KNO_3	101.11	1883.58		1883.58	1883.60		1883.60	0.0		
Rubidium Nitrate	$RbNO_3$	147.48	9.55		9.55	9.53		9.53	-0.2		
Zinc Nitrate	$Zn(NO_3)_2.6H_2O$	297.47	8.44	3.06	5.38	8.47	3.08	5.39	0.4		
Zirconyl Nitrate	$ZrO(NO_3)_2.H_2O$	249.23	12.25	0.88	11.37	12.27	0.89	11.38	0.2		
EDTA	$Na_2C_{10}H_{14}N_2O_8.2H_2O$	372.24	1373.63	132.85	1240.78	1373.60	132.84	1240.76	0.0	170	
HEDTA	$C_{10}H_{18}N_2O_7$	278.26	194.19		194.19	216.70		194.18	0.0	29	(8)
Sodium Gluconate	$CH_2OH(CHOH)_4COONa$	218.14	810.73		810.73	810.70		810.70	0.0	85	
Citric Acid	$HOC(CH_2CO_2H)_2CO_2H$	192.13	3250.38		3250.38	3250.30		3250.30	0.0		
Nitrilotriacetic Acid	$N(CH_2COOH)_3$	191.14	107.47		107.47	107.40		107.40	-0.1		
Iminodiacetic Acid	$HN(CH_2CO_2H)_2$	133.10	1830.68		1830.68	1830.60		1830.60	0.0		
Succinic Acid	$C_4H_6O_4$	118.04	14.80		14.80	14.81		14.81	0.1		
Glutaric Acid	$C_5H_8O_4$	132.12	43.82		43.82	43.82		43.82	0.0		
Adipic Acid	$C_6H_{10}O_4$	146.14	164.93		164.93	164.90		164.90	0.0		
Azelaic Acid	$C_9H_{16}O_4$	188.22	689.69		689.69	689.70		689.70	0.0		
Suberic Acid	$C_8H_{14}O_4$	174.20	1213.14		1213.14	1213.10		1213.10	0.0		
Ammonium Acetate	NH_4CH_3COO	77.08	416.09		416.09	416.10		416.10	0.0		
Notes: (8)	Only 99.16 grams of HEDA was available for mixing this batch. Trisodium HEDTA ($Na_3C_{10}H_{15}N_2O_7$ with formula weight 344.21) was available, so (194.19-99.16)*(344.21/278.26) = 117.54 grams of Trisodium HEDTA was substituted.										

Batch #3C Simulant Remediation											
			Recipe amounts for 812 liters			Actual amounts added by EDL					Notes
			Compound	Water	Non-water	Compound	Water	Non-water			
Compounds	Formula	Formula Weight	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	% Extra	Na content	
Boric acid	H_3BO_3	61.83	79.02		79.02	79.00		79.00	0.0		
Sodium Chloride	NaCl	58.44	3535.58		3535.58	3535.60		3535.60	0.0	1391	
Sodium Fluoride	NaF	41.99	1235.85		1235.85	1235.50		1235.50	0.0	676	
Sodium Sulfate	Na_2SO_4	142.04	7317.24		7317.24	7317.30		7317.30	0.0	2369	
Potassium Molybdate	K_2MoO_4	238.14	36.55		36.55	36.50		36.50	-0.1		
Sodium Hydroxide	NaOH	40.00	26654.63		26654.63	26700.00		26700.00	0.2	15346	
Sodium Phosphate	$Na_3PO_4.12H_2O$	380.12	9376.45	5328.09	4048.36	9300.00	5284.65	4015.35	-0.8	1687	
Sodium Tungstate	$Na_2WO_4.2H_2O$	329.86	199.52	21.78	177.74	199.50	21.77	177.73	0.0	28	
Sodium Metasilicate	$Na_2SiO_3.9H_2O$	284.14	67.18	38.30	28.88	67.10	38.26	28.84	-0.1	11	
Sodium Formate	NaHCOO	68.01	5314.92		5314.92	5314.90		5314.90	0.0	1797	
Sodium Glycolate	$HOCH_2COONa$	98.01	5361.59	0.00	5361.59	5361.60		5361.60	0.0	1258	
Sodium Acetate	$NaCH_3COO.3H_2O$	136.08	0.42	0.17	0.25	0.43	0.17	0.26	2.4	0	
Sodium Oxalate	$Na_2C_2O_4$	134.00	267.24		267.24	267.20		267.20	0.0	92	
Sodium Chromate	Na_2CrO_4	161.97	311.57		311.57	311.60		311.60	0.0	88	
Sodium Carbonate	Na_2CO_3	105.99	30115.85		30115.85	30100.00		30100.00	-0.1	13058	
Sodium Nitrate	$NaNO_3$	84.99	40472.77		40472.77	40400.00		40400.00	-0.2	10928	
Sodium Nitrite	$NaNO_2$	69.00	32945.07		32945.07	32900.00		32900.00	-0.1	10962	
Totals added during remediation			520603.80	315219.19	205384.61	520545.35	315245.64	205277.19		59975	
Optima Simulant used for Batch 3C			537504.20	347759.70	189744.50	537500.00	347059.01	190440.988		62434	
Total Remediated Simulant for Batch 3C			1058108.00	662978.90	395129.11	1058045.35	662304.65	395718.18		122408	
Expected density, gm/ml			1.3026			1.3036					
Water charged to tank to dilute to 6.0 M Na			67692	67692		68000	68000				
Batch 3C Supernate after dilution			1125800.00			1126045.35					
Expected density after dilution, gm/ml			1.2793			1.2801					

Batch #3C Entrained solids			Recipe amounts for 812 liters			Actual amounts added by EDL					Notes
			Compound	Water	Non-water	Compound	Water	Non-water			
Compounds	Formula	Formula Weight	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	% Extra	Na content	
Aluminum Oxide	Al_2O_3	101.96	174.3	0.00	174.30	174.3	0.00	174.30	0.0		
Barium Sulfate	$BaSO_4$	233.4	0.23	0.00	0.23	0.24	0.00	0.24	4.3		
Calcium Oxalate	$CaC_2O_4.H_2O$	146.11	1.5	0.18	1.32	1.5	0.18	1.32	0.0		
Calcium Tungstate	$CaWO_4$	287.93	1.27	0.00	1.27	1.27	0.00	1.27	0.0		
Cerium Oxalate	$Ce(C_2O_4)_3.9H_2O$	544.29	0.23	0.07	0.16	0.23	0.07	0.16	0.0		
Chromic Oxide	Cr_2O_3	151.99	10.72	0.00	10.72	10.72	0.00	10.72	0.0		
Ferric Hydroxide	FeO(OH)	88.85	7.84	0.00	7.84	7.85	0.00	7.85	0.1		
Lanthanum Oxalate	$La_2(C_2O_4)_3.10H_2O$	722.03	0.23	0.06	0.17	0.23	0.06	0.17	0.0		
Lead Sulfate	$PbSO_4$	303.25	0.92	0.00	0.92	0.93	0.00	0.93	1.1		
Manganese Dioxide	MnO_2	86.94	1.73	0.00	1.73	1.74	0.00	1.74	0.6		
Neodymium Oxalate	$Nd_2(C_2O_4)_3.10H_2O$	732.69	0.46	0.11	0.35	0.46	0.11	0.35	0.0		
Nickel Oxide	NiO	74.71	0.12	0.00	0.12	0.13	0.00	0.13	8.3		
Silicon Oxide	SiO_2	60.09	0.58	0.00	0.58	0.58	0.00	0.58	0.0		
Sodium Carbonate	$Na_2CO_3.H_2O$	124.01	492.36	71.47	420.89	492.40	71.47	420.93	0.0	183	
Sodium Fluoride	NaF	41.99	36.31	0.00	36.31	36.30	0.00	36.30	0.0	20	
Sodium Oxalate	$Na_2C_2O_4$	134.00	185.60	0.00	185.60	185.60	0.00	185.60	0.0	64	
Sodium Phosphate	$Na_3PO_4.12H_2O$	380.12	141.56	80.44	61.12	141.60	80.46	61.14	0.0	26	
Sodium Sulfate	$Na_2SO_4.10H_2O$	322.04	96.26	53.80	42.46	96.30	53.83	42.47	0.0	14	
Zinc Oxalate	$ZnC_2O_4.2H_2O$	189.45	0.23	0.04	0.19	0.24	0.05	0.19	4.3		
Zirconium Oxide	ZrO_2	60.09	0.23	0.00	0.23	0.23	0.00	0.23	0.0		
Total solids added			1152.68	206.18	946.50	1152.85	206.23	946.62		306	
Totals in simulant batch 3C			1126952.68	730877.07	396075.61	1127198.20	730510.88	396664.80		122714	

Batch #3B simulant remediation and entrained solids

Batch #3B Simulant Remediation			Recipe amounts for 927 liters			Actual amounts added by EDL					Notes
			Compound	Water	Non-water	Compound	Water	Non-water			
Compounds	Formula	Formula Weight	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	% Extra	Na content	
Water charged to tank			323339.73	323339.73		323400.00	323400.00				
Aluminum Nitrate	$Al(NO_3)_3.9H_2O$	375.13	67665.89	29221.53	38444.36	67700.00	29236.26	38463.74	0.1		
Cadmium Nitrate	$Cd(NO_3)_2.4H_2O$	308.48	126.52	29.53	96.99	126.50	29.53	96.97	0.0		
Calcium Nitrate	$Ca(NO_3)_2.4H_2O$	236.15	1312.15	400.06	912.09	1312.10	400.05	912.05	0.0		
Cerium Nitrate	$Ce(NO_3)_3.6H_2O$	434.22	104.75	26.05	78.70	104.90	26.09	78.81	0.1		
Cesium Nitrate	$CsNO_3$	194.91	4.72		4.72	4.71		4.71	-0.2		
Cobalt Nitrate	$Co(NO_3)_3.6H_2O$	353.03	12.48	3.82	8.66	12.48	3.82	8.66	0.0		
Copper Nitrate	$Cu(NO_3)_2.2.5H_2O$	241.60	40.22	7.49	32.73	40.30	7.51	32.79	0.2		
Ferric Nitrate	$Fe(NO_3)_3.9H_2O$	403.99	152.10	60.99	91.11	152.10	60.99	91.11	0.0		
Lanthanum Nitrate	$La(NO_3)_3.6H_2O$	433.01	77.98	19.45	58.53	77.80	19.40	58.40	-0.2		
Lead nitrate	$Pb(NO_3)_2$	331.20	136.50		136.50	136.50		136.50	0.0		
Manganous Chloride	$MnCl_2.4H_2O$	197.90	60.62	22.05	38.57	60.70	22.08	38.62	0.1		
Neodymium Nitrate	$Nd(NO_3)_2.6H_2O$	376.36	186.61	53.55	133.06	186.70	53.58	133.12	0.0		
Nickel Nitrate	$Ni(NO_3)_2.6H_2O$	290.81	951.56	353.39	598.17	951.60	353.40	598.20	0.0		
Potassium Nitrate	KNO_3	101.11	2150.24		2150.24	2150.30		2150.30	0.0		
Rubidium Nitrate	$RbNO_3$	147.48	10.90		10.90	10.87		10.87	-0.3		
Zinc Nitrate	$Zn(NO_3)_2.6H_2O$	297.47	9.64	3.50	6.14	9.65	3.50	6.15	0.1		
Zirconyl Nitrate	$ZrO(NO_3)_2.H_2O$	249.23	13.99	1.01	12.98	13.99	1.01	12.98	0.0		
EDTA	$Na_2C_{10}H_{14}N_2O_8.2H_2O$	372.24	1568.10	151.65	1416.45	1568.20	151.66	1416.54	0.0	194	
HEDTA	$Na_3C_{10}H_{15}N_2O_7$	344.21	221.68		221.68	221.70		221.70	0.0	44	
Sodium Gluconate	$CH_2OH(CHOH)_4COONa$	218.14	925.51		925.51	925.50		925.50	0.0	98	
Citric Acid	$HOC(CH_2CO_2H)_2CO_2H$	192.13	3710.54		3710.54	3710.50		3710.50	0.0		
Nitrilotriacetic Acid	$N(CH_2COOH)_3$	191.14	122.69		122.69	122.60		122.60	-0.1		
Iminodiacetic Acid	$HN(CH_2CO_2H)_2$	133.10	2089.85		2089.85	2089.90		2089.90	0.0		
Succinic Acid	$C_4H_6O_4$	118.04	16.89		16.89	16.80		16.80	-0.5		
Glutaric Acid	$C_5H_8O_4$	132.12	50.03		50.03	50.10		50.10	0.1		
Adipic Acid	$C_6H_{10}O_4$	146.14	188.28		188.28	188.30		188.30	0.0		
Azelaic Acid	$C_9H_{16}O_4$	188.22	787.34		787.34	787.40		787.40	0.0		
Suberic Acid	$C_8H_{14}O_4$	174.20	1384.89		1384.89	1384.90		1384.90	0.0		
Ammonium Acetate	NH_4CH_3COO	77.08	475.00		475.00	475.00		475.00	0.0		
Boric acid	H_3BO_3	61.83	90.20		90.20	90.20		90.20	0.0		
Sodium Chloride	NaCl	58.44	4036.12		4036.12	4036.10		4036.10	0.0	1588	
Sodium Fluoride	NaF	41.99	1410.82		1410.82	1410.90		1410.90	0.0	1545	
Sodium Sulfate	Na_2SO_4	142.04	8353.16		8353.16	8400.00		8400.00	0.6		
Potassium Molybdate	K_2MoO_4	238.14	41.73		41.73	41.70		41.70	-0.1		

Batch #3B Simulant Remediation											
			Recipe amounts for 927 liters			Actual amounts added by EDL					Notes
			Compound	Water	Non-water	Compound	Water	Non-water			
Compounds	Formula	Formula Weight	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	% Extra	Na content	
Sodium Hydroxide	$NaOH$	40.00	30428.17		30428.17	30400.00		30400.00	-0.1	17472	
Sodium Phosphate	$Na_3PO_4.12H_2O$	380.12	10703.89	6082.40	4621.49	10700.00	6080.19	4619.81	0.0	1941	
Sodium Tungstate	$Na2WO_4.2H_2O$	329.86	227.77	24.86	202.91	227.70	24.85	202.85	0.0	32	
Sodium Metasilicate	$Na_2SiO_3.9H_2O$	284.14	76.69	43.72	32.97	76.70	43.73	32.97	0.0	12	
Sodium Formate	$NaHCOO$	68.01	6067.36		6067.36	6067.20		6067.20	0.0	2051	
Sodium Glycolate	$HOCH_2COONa$	98.01	6120.65	0.00	6120.65	6120.60		6120.60	0.0	1436	
Sodium Acetate	$NaCH_3COO.3H_2O$	136.08	0.48	0.19	0.29	0.48	0.19	0.29	0.0	0	
Sodium Oxalate	$Na_2C_2O_4$	134.00	305.08		305.08	305.00		305.00	0.0	105	
Sodium Chromate	Na_2CrO_4	161.97	355.68		355.68	355.60		355.60	0.0	101	
Sodium Carbonate	Na_2CO_3	105.99	34379.41		34379.41	34400.00		34400.00	0.1	14923	
Sodium Nitrate	$NaNO_3$	84.99	46202.57		46202.57	46200.00		46200.00	0.0	12497	
Sodium Nitrite	$NaNO_2$	69.00	37609.16		37609.16	37600.00		37600.00	0.0	12528	
Totals added during remediation			594306.34	359844.99	234461.35	594424.28	359917.84	234506.43		66567	
Optima Simulant added			613599.70	396992.713	216606.99	613900.00	397038.845	216861.16		70474	
Total Remediated Simulant			1207906.04	756837.70	451068.34	1208324.28	756956.69	451367.59		137041	
Calculated density			1.3090			1.3093					
Less Remediated simulant used with Batch 3A			118500			118500.00					
Less material to CUF and samples			17724			17724.00					
Total remediated simulant used in Batch 3B			1071682.04			1072100.28				121591	
Water charged to tank to dilute to 6.0 M Na			67692	67692		68000.00	68000				
Batch 3B Supernate after dilution			1139374.04			1140100.28					
Expected density after dilution, gm/ml			1.2854			1.2856					

Batch #3B Entrained solids											
			Recipe amounts for 812 liters			Actual amounts added by EDL					Notes
			Compound	Water	Non-water	Compound	Water	Non-water			
Compounds	Formula	Formula Weight	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	% Extra	Na content	
Aluminum Oxide	Al_2O_3	102	174.3	0.00	174.30	174.30	0.00	174.30	0.0		
Barium Sulfate	$BaSO_4$	233.4	0.23	0.00	0.23	0.23	0.00	0.23	0.0		
Calcium Oxalate	$CaC_2O_4.H_2O$	146.1	1.5	0.18	1.32	1.51	0.19	1.32	0.6		
Calcium Tungstate	$CaWO_4$	287.9	1.27	0.00	1.27	1.27	0.00	1.27	0.1		
Cerium Oxalate	$Ce(C_2O_4)_3.xH_2O$	544.3	0.23	0.07	0.16	0.23	0.07	0.16	-0.8		
Chromic Oxide	Cr_2O_3	152	10.72	0.00	10.72	10.73	0.00	10.73	0.1		
Ferric Hydroxide	$FeO(OH)$	88.85	7.84	0.00	7.84	7.85	0.00	7.85	0.1		
Lanthanum Oxalate	$La_2(C_2O_4)_3.10H_2O$	722	0.23	0.06	0.17	0.23	0.06	0.18	1.7		
Lead Sulfate	$PbSO_4$	303.3	0.92	0.00	0.92	0.93	0.00	0.93	0.7		
Manganese Dioxide	MnO_2	86.94	1.73	0.00	1.73	1.74	0.00	1.74	0.6		
Neodymium Oxalate	$Nd_2(C_2O_4)_3.10H_2O$	732.7	0.46	0.11	0.35	0.46	0.11	0.35	0.0		
Nickel Oxide	NiO	74.71	0.12	0.00	0.12	0.13	0.00	0.13	6.8		
Silicon Oxide	SiO_2	60.09	0.58	0.00	0.58	0.59	0.00	0.59	1.2		
Sodium Carbonate	$Na_2CO_3.H_2O$	124.01	492.36	71.47	420.89	492.40	71.47	420.93	0.0	91	
Sodium Fluoride	NaF	41.99	36.31	0.00	36.31	36.30	0.00	36.30	0.0	20	
Sodium Oxalate	$Na_2C_2O_4$	134.00	185.60	0.00	185.60	185.60	0.00	185.60	0.0	64	
Sodium Phosphate	$Na_3PO_4.12H_2O$	380.12	141.56	80.44	61.12	141.60	80.46	61.14	0.0	26	
Sodium Sulfate	$Na_2SO_4.10H_2O$	322.04	96.26	53.80	42.46	96.30	53.83	42.47	0.0	14	
Zinc Oxalate	$ZnC_2O_4.2H_2O$	189.5	0.23	0.04	0.19	0.24	0.04	0.19	2.7		
Zirconium Oxide	ZrO_2	60.09	0.23	0.00	0.23	0.23	0.00	0.23	1.0		
Total solids added			1152.68	206.18	946.50	1152.85	206.23	946.62		214	
Total material in simulant			1140526.72			1141253.13				121806	

Batch #3A simulant remediation and entrained solids

Batch #3A Simulant Remediation											Notes
			Recipe amounts for 757.1 liters			Actual amounts added by EDL					
			Compound	Water	Non-water	Compound	Water	Non-water			
Compounds	Formula	Formula Weight	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	% Extra	Na content	
Water charged to tank			263990.83	263990.83		264090.05	264090.05				
Aluminum Nitrate	$Al(NO_3)_3.9H_2O$	375.13	55245.77	23857.90	31387.87	55262.45	23865.11	31397.34	0.0		
Cadmium Nitrate	$Cd(NO_3)_2.4H_2O$	308.48	103.30	24.11	79.19	103.34	24.12	79.22	0.0		
Calcium Nitrate	$Ca(NO_3)_2.4H_2O$	236.15	1071.30	326.63	744.67	1072.36	326.95	745.41	0.1		
Cerium Nitrate	$Ce(NO_3)_3.6H_2O$	434.22	85.04	21.15	63.89	85.56	21.28	64.28	0.6		
Cesium Nitrate	$CsNO_3$	194.91	3.85		3.85	3.87		3.87	0.4		
Cobalt Nitrate	$Co(NO_3)_3.6H_2O$	353.03	10.19	3.12	7.07	10.19	3.12	7.07	0.0		
Copper Nitrate	$Cu(NO_3)_2.2.5H_2O$	241.60	32.83	6.11	26.72	33.06	6.16	26.90	0.7		
Ferric Nitrate	$Fe(NO_3)_3.9H_2O$	403.99	124.18	49.80	74.38	124.06	49.75	74.31	-0.1		
Lanthanum Nitrate	$La(NO_3)_3.6H_2O$	433.01	63.30	15.79	47.51	63.63	15.87	47.76	0.5		
Lead nitrate	$Pb(NO_3)_2$	331.20	111.44		111.44	111.53		111.53	0.1		
Manganous Chloride	$MnCl_2.4H_2O$	197.90	49.49	18.01	31.48	49.49	18.01	31.48	0.0		
Neodymium Nitrate	$Nd(NO_3)_2.6H_2O$	376.36	151.48	43.47	108.01	152.86	43.86	109.00	0.9		
Nickel Nitrate	$Ni(NO_3)_2.6H_2O$	290.81	776.90	288.52	488.38	776.75	288.47	488.28	0.0		
Potassium Nitrate	KNO_3	101.11	1755.56		1755.56	1755.26		1755.26	0.0		
Rubidium Nitrate	$RbNO_3$	147.48	8.90		8.90	8.90		8.90	0.0		
Zinc Nitrate	$Zn(NO_3)_2.6H_2O$	297.47	7.87	2.86	5.01	7.86	2.85	5.01	-0.1		
Zirconyl Nitrate	$ZrO(NO_3)_2.H_2O$	249.23	11.43	0.83	10.60	11.43	0.83	10.60	0.0		
EDTA	$Na_2C_{10}H_{14}N_2O_8.2H_2O$	372.24	1280.27	123.82	1156.45	1280.08	123.80	1156.28	0.0	158	
HEDTA	$Na_3C_{10}H_{15}N_2O_7$	344.21	223.89		223.89	181.06		181.06	-19.1	36	(8)
Sodium Gluconate	$CH_2OH(CHOH)_4COONa$	218.14	755.63		755.63	755.58		755.58	0.0	80	
Citric Acid	$HOC(CH_2CO_2H)_2CO_2H$	192.13	3029.47		3029.47	3029.06		3029.06	0.0		
Nitrilotriacetic Acid	$N(CH_2COOH)_3$	191.14	100.17		100.17	100.09		100.09	-0.1		
Iminodiacetic Acid	$HN(CH_2CO_2H)_2$	133.10	1706.26		1706.26	1706.04		1706.04	0.0		
Succinic Acid	$C_4H_6O_4$	118.04	13.79		13.79	13.86		13.86	0.5		
Glutaric Acid	$C_5H_8O_4$	132.12	40.84		40.84	40.83		40.83	0.0		
Adipic Acid	$C_6H_{10}O_4$	146.14	153.73		153.73	153.68		153.68	0.0		
Azelaic Acid	$C_9H_{16}O_4$	188.22	642.82		642.82	642.74		642.74	0.0		
Suberic Acid	$C_8H_{14}O_4$	174.20	1130.69		1130.69	1130.75		1130.75	0.0		
Ammonium Acetate	NH_4CH_3COO	77.08	387.81		387.81	387.93		387.93	0.0		
Boric acid	H_3BO_3	61.83	73.65		73.65	73.62		73.62	0.0		
Sodium Chloride	NaCl	58.44	3295.29		3295.29	3294.84		3294.84	0.0	1296	
Sodium Fluoride	NaF	41.99	1151.86		1151.86	1151.74		1151.74	0.0	631	
Sodium Sulfate	Na_2SO_4	142.04	6819.93		6819.93	6809.43		6809.43	-0.2		
Potassium Molybdate	K_2MoO_4	238.14	34.07		34.07	34.10		34.10	0.1		

Notes: (8) Discrepancy in HEDTA caused by a mixture of the HEDTA (non-trisodium version and the trisodium version, 10% less HEDTA) used in mixing batch

Batch #3A Simulant Remediation											Notes
			Recipe amounts for 757.1 liters			Actual amounts added by EDL					
			Compound	Water	Non-water	Compound	Water	Non-water			
Compounds	Formula	Formula Weight	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	% Extra	Na content	
Sodium Hydroxide	NaOH	40.00	24843.06		24843.06	24874.03		24874.03	0.1	14296	
Sodium Phosphate	$Na_3PO_4.12H_2O$	380.12	8739.19	4965.97	3773.22	8756.89	4976.03	3780.86	0.2	1589	
Sodium Tungstate	Na2WO4.2H2O	329.86	185.96	20.30	165.66	186.00	20.30	165.70	0.0	26	
Sodium Metasilicate	Na_2SiO3.9H2O	284.14	62.62	35.70	26.92	62.62	35.70	26.92	0.0	10	
Sodium Formate	NaHCOO	68.01	4953.69		4953.69	4940.75		4940.75	-0.3	1670	
Sodium Glycolate	$HOCH_2COONa$	98.01	4997.20	0.00	4997.20	4945.99		4945.99	-1.0	1160	
Sodium Acetate	$NaCH_3COO.3H_2O$	136.08	0.39	0.15	0.24	0.39	0.15	0.24	0.0	0	
Sodium Oxalate	$Na_2C_2O_4$	134.00	249.08		249.08	249.00		249.00	0.0	85	
Sodium Chromate	Na_2CrO_4	161.97	290.40		290.40	290.37		290.37	0.0	82	
Sodium Carbonate	Na_2CO_3	105.99	28069.05		28069.05	28054.14		28054.14	-0.1	12170	
Sodium Nitrate	$NaNO_3$	84.99	37722.06		37722.06	37738.86		37738.86	0.0	10208	
Sodium Nitrite	$NaNO_2$	69.00	30705.98		30705.98	30663.83		30663.83	-0.1	10217	
Totals added during remediation			485262.51	293795.06	191467.45	485270.95	293912.40	191358.55		53716	
Optima Simulant added			500973.07	324124.436	176848.634	500929.02	323975.044	176953.976		77777	
Total Remediated Simulant			986235.58	617919.50	368316.09	986199.97	617887.45	368312.52		131492	
Expected density, gm/ml			1.3090			1.3090					
Water charged to tank to dilute to 6.0 M Na			62700.00	62700.00		62700.00	62700.00				
Batch 3A Supernate after dilution			1048935.58			1048899.97					
Expected density after dilution, gm/ml			1.2853			1.2853					

Batch #3A Entrained solids											
			Recipe amounts for 812 liters			Actual amounts added by EDL					Notes
			Compound	Water	Non-water	Compound	Water	Non-water			
Compounds	Formula	Formula Weight	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	% Extra	Na content	
Aluminum Oxide	Al2O3	101.96	161.53		174.3	161.5		174.3	0.0		
Barium Sulfate	BaSO4	233.4	0.21		0.23	0.21		0.24	4.3		
Calcium Oxalate	CaC2O4.H2O	146.11	1.39	0.17	1.5	1.39	0.17	1.5	0.0		
Calcium Tungstate	CaWO4	287.93	1.18		174.3	1.18		174.3	0.0		
Cerium Oxalate	Ce(C2O4)3.9H2O	544.29	0.21		174.3	0.21		174.3	0.0		
Chromic Oxide	Cr2O3	151.99	9.94		174.3	9.94		174.3	0.0		
Ferric Hydroxide	FeO(OH)	88.85	7.26		174.3	7.26		174.3	0.0		
Lanthanum Oxalate	La2(C2O4)3.10H2O	722.03	0.21	0.05	174.3	0.21	0.05	174.3	0.0		
Lead Sulfate	PbSO4	303.25	0.85		0.23	0.85		0.24	4.3		
Manganese Dioxide	MnO2	86.94	1.6		174.3	1.6		174.3	0.0		
Neodymium Oxalate	Nd2(C2O4)3.10H2O	732.69	0.43	0.11	174.3	0.43	0.11	174.3	0.0		
Nickel Oxide	NiO	74.71	0.11		174.3	0.11		174.3	0.0		
Silicon Oxide	SiO2	60.09	0.53		174.3	0.53		174.3	0.0		
Sodium Carbonate	Na2CO3.H2O	124.01	456.29	66.23	390.06	456.30	66.23	390.07	0.0	169	
Sodium Fluoride	NaF	41.99	33.65		33.65	33.60		33.60	-0.1	18	
Sodium Oxalate	$Na_2C_2O_4$	134.00	172.00		172.00	172.00		172.00	0.0	59	
Sodium Phosphate	$Na_3PO_4.12H_2O$	380.12	131.19	74.55	56.64	131.20	74.55	56.65	0.0	24	
Sodium Sulfate	$Na2SO_4.10H_2O$	322.04	89.21	49.86	39.35	89.20	49.86	39.34	0.0	13	
Zinc Oxalate	ZnC2O4.2H2O	189.45	0.21	0.04	1.5	0.21	0.04	1.5	0.0		
Zirconium Oxide	ZrO2	60.09	0.21		174.3	0.21		174.3	0.0		
Total solids added			1068.21	191.01	2612.46	1068.14	191.01	2612.44		283	
Total material in simulant			1050003.79	680810.51	370928.55	1049968.11	680778.46	370924.96		131776	

Batch #4A simulant remediation and entrained solids

Batch #4A Simulant Remediation											
			Recipe amounts for 812 liters			Actual amounts added by EDL					Notes
			Compound	Water	Non-water	Compound	Water	Non-water			
Compounds	Formula	Formula Weight	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	% Extra	Na content	
Water charged to tank			283241.13	283241.13		283000	283000				
Aluminum Nitrate	$Al(NO_3)_3.9H_2O$	375.13	59274.31	25597.63	33676.68	59300	25608.72	33691.28	0.0		
Cadmium Nitrate	$Cd(NO_3)_2.4H_2O$	308.48	110.83	25.87	84.96	110.9	25.84	84.86	-0.1		
Calcium Nitrate	$Ca(NO_3)_2.4H_2O$	236.15	1149.42	350.45	798.97	1149.3	350.44	798.96	0.0		
Cerium Nitrate	$Ce(NO_3)_3.6H_2O$	434.22	91.76	22.82	68.94	91.8	22.81	68.89	-0.1		
Cesium Nitrate	$CsNO_3$	194.91	4.13		4.13	4.13		4.13	0.0		
Cobalt Nitrate	$Co(NO_3)_3.6H_2O$	353.03	10.93	3.34	7.59	10.9	3.33	7.57	-0.3		
Copper Nitrate	$Cu(NO_3)_2.2.5H_2O$	241.6	35.23	6.56	28.67	35.2	6.57	28.73	0.2		
Ferric Nitrate	$Fe(NO_3)_3.9H_2O$	403.99	133.24	53.43	79.81	133.2	53.41	79.79	0.0		
Lanthanum Nitrate	$La(NO_3)_3.6H_2O$	433.01	68.31	17.04	51.27	68.3	17.04	51.26	0.0		
Lead nitrate	$Pb(NO_3)_2$	331.2	119.57		119.57	119.6		119.6	0.0		
Manganous Chloride	$MnCl_2.4H_2O$	197.9	53.1	19.32	33.78	53.1	19.32	33.78	0.0		
Neodymium Nitrate	$Nd(NO_3)_2.6H_2O$	376.36	163.46	46.91	116.55	163.5	46.92	116.58	0.0		
Nickel Nitrate	$Ni(NO_3)_2.6H_2O$	290.81	833.55	309.56	523.99	833.6	309.58	524.02	0.0		
Potassium Nitrate	KNO_3	101.11	1883.58		1883.58	1883.6		1883.6	0.0		
Rubidium Nitrate	$RbNO_3$	147.48	9.55		9.55	9.58		9.58	0.3		
Zinc Nitrate	$Zn(NO_3)_2.6H_2O$	297.47	8.44	3.06	5.38	8.44	3.08	5.39	0.2		
Zirconyl Nitrate	$ZrO(NO_3)_2.H_2O$	249.23	12.25	0.88	11.37	12.3	0.89	11.38	0.1		
EDTA	$Na_2C_{10}H_{14}N_2O_8.2H_2O$	372.24	1373.63	132.85	1240.78	1373.6	132.84	1240.76	0.0	170	
HEDTA	$Na_3C_{10}H_{15}N_2O_7$	344.21	216.73		216.73	216.7		216.7	0.0	43	
Sodium Gluconate	$CH_2OH(CHOH)_4COONa$	218.14	810.73		810.73	810.7		810.7	0.0	85	
Citric Acid	$HOC(CH_2CO_2H)_2CO_2H$	192.13	3250.38		3250.38	3250.3		3250.3	0.0		
Nitrilotriacetic Acid	$N(CH_2COOH)_3$	191.14	107.47		107.47	107.5		107.5	0.0		
Iminodiacetic Acid	$HN(CH_2CO_2H)_2$	133.1	1830.68		1830.68	1830.7		1830.7	0.0		
Succinic Acid	$C_4H_6O_4$	118.04	14.8		14.8	14.8		14.8	0.0		
Glutaric Acid	$C_5H_8O_4$	132.12	43.82		43.82	43.8		43.8	0.0		
Adipic Acid	$C_6H_{10}O_4$	146.14	164.93		164.93	164.9		164.9	0.0		
Azelaic Acid	$C_9H_{16}O_4$	188.22	689.69		689.69	689.7		689.7	0.0		
Suberic Acid	$C_8H_{14}O_4$	174.2	1213.14		1213.14	1213.1		1213.1	0.0		
Ammonium Acetate	NH_4CH_3COO	77.08	416.09		416.09	416.1		416.1	0.0		
Boric acid	H_3BO_3	61.83	79.02		79.02	79		79	0.0		
Sodium Chloride	NaCl	58.44	3535.58		3535.58	3535.6		3535.6	0.0	1391	
Sodium Fluoride	NaF	41.99	1235.85		1235.85	1235.8		1235.8	0.0	1353	
Sodium Sulfate	Na_2SO_4	142.04	7317.24		7317.24	7300		7300	-0.2		
Potassium Molybdate	K_2MoO_4	238.14	36.55		36.55	36.5		36.5	-0.1		

Batch #4A Simulant Remediation											Notes
			Recipe amounts for 812 liters			Actual amounts added by EDL					
			Compound	Water	Non-water	Compound	Water	Non-water			
Compounds	Formula	Formula Weight	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	% Extra	Na content	
Sodium Hydroxide	$NaOH$	40	26654.63		26654.63	26700		26700	0.2	15346	
Sodium Phosphate	$Na_3PO_4.12H_2O$	380.12	9376.45	5328.09	4048.36	9400	5284.65	4015.35	-0.8	1706	
Sodium Tungstate	$Na_2WO_4.2H_2O$	329.86	199.52	21.78	177.74	199.5	21.77	177.73	0.0	28	
Sodium Metasilicate	$Na_2SiO_3.9H_2O$	284.14	67.18	38.3	28.88	67.2	38.26	28.84	-0.1	11	
Sodium Formate	$NaHCOO$	68.01	5314.92		5314.92	5300		5300	-0.3	1792	
Sodium Glycolate	$HOCH_2COONa$	98.01	5361.59	0	5361.59	5400		5400	0.7	1267	
Sodium Acetate	$NaCH_3COO.3H_2O$	136.08	0.42	0.17	0.25	0.42	0.17	0.26	4.0	0	
Sodium Oxalate	$Na_2C_2O_4$	134	267.24		267.24	267.2		267.2	0.0	92	
Sodium Chromate	Na_2CrO_4	161.97	311.57		311.57	311.6		311.6	0.0	88	
Sodium Carbonate	Na_2CO_3	105.99	30115.85		30115.85	30100		30100	-0.1	13058	
Sodium Nitrate	$NaNO_3$	84.99	40472.77		40472.77	40500		40500	0.1	10955	
Sodium Nitrite	$NaNO_2$	69	32945.07		32945.07	32900		32900	-0.1	10962	
Totals added during remediation			520626.33	315219.19	205407.14	520452.17	314945.64	205406.34		58346	
Optima Simulant used to mix Batch #4A			537504.2	347759.70	189744.50	537500	347627.27	189872.73		83473	
Total Remediated Simulant available for Batch #4A			1058130.53	662978.89	395151.64	1057952.17	662572.91	395279.074		141819	
Expected density, gm/ml			1.3090			1.3094					
Remediated simulant actually used for Batch #4A			718661.00	450281.95	268379.05	720400.00	451171.17	269160.604		96570	
Volume of simulant for Batch #4A, liters			549			550					
Water charged to tank to dilute to 6.0 M Na			27880	27880		28000	28000				
Batch 4A Supernate after dilution			746541.00	478161.95	268379.05	748400.00	479171.17	269160.60		96570	
Expected density after dilution, gm/ml			1.2941			1.2945					

Batch #4A Entrained solids											Notes
			Recipe amounts for Batch 4A			Actual amounts added by EDL					
			Compound	Water	Non-water	Compound	Water	Non-water			
Compounds	Formula	Formula Weight	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	mass, grams	% Extra	Na content	
Aluminum Oxide	Al_2O_3	101.96	116.86	0.00	116.86	116.9	0.00	116.90	0.0		
Barium Sulfate	$BaSO_4$	233.4	0.15	0.00	0.15	0.1561	0.00	0.16	4.1		
Calcium Oxalate	$CaC_2O_4.H_2O$	146.11	1.0	0.12	0.88	1.0154	0.13	0.89	1.5		
Calcium Tungstate	$CaWO_4$	287.93	0.85	0.00	0.85	0.8528	0.00	0.85	0.3		
Cerium Oxalate	$Ce(C_2O_4)_3.xH_2O$	544.29	0.15	0.04	0.11	0.1509	0.04	0.11	0.6		
Chromic Oxide	Cr_2O_3	151.99	7.19	0.00	7.19	7.1938	0.00	7.19	0.1		
Ferric Hydroxide	$FeO(OH)$	88.85	5.26	0.00	5.26	5.2638	0.00	5.26	0.1		
Lanthanum Oxalate	$La_2(C_2O_4)_3.10H_2O$	722.03	0.15	0.04	0.11	0.1565	0.04	0.12	4.3		
Lead Sulfate	$PbSO_4$	303.25	0.62	0.00	0.62	0.627	0.00	0.63	1.1		
Manganese Dioxide	MnO_2	86.94	1.16	0.00	1.16	1.1613	0.00	1.16	0.1		
Neodymium Oxalate	$Nd_2(C_2O_4)_3.10H_2O$	732.69	0.31	0.08	0.23	0.3133	0.08	0.24	1.1		
Nickel Oxide	NiO	74.71	0.08	0.00	0.08	0.0862	0.00	0.09	7.8		
Silicon Oxide	SiO_2	60.09	0.39	0.00	0.39	0.399	0.00	0.40	2.3		
Sodium Carbonate	$Na_2CO_3.H_2O$	124.01	330.11	47.92	282.19	330.1	47.91	282.19	0.0	122	
Sodium Fluoride	NaF	41.99	24.35	0.00	24.35	24.4	0.00	24.40	0.2	13	
Sodium Oxalate	$Na_2C_2O_4$	134	124.44	0.00	124.44	124.5	0.00	124.50	0.0	43	
Sodium Phosphate	$Na_3PO_4.12H_2O$	380.12	94.91	53.93	40.98	94.9	53.93	40.97	0.0	17	
Sodium Sulfate	$Na_2SO_4.10H_2O$	322.04	64.54	36.07	28.47	64.5	36.05	28.45	-0.1	9	
Zinc Oxalate	$ZnC_2O_4.2H_2O$	189.45	0.15	0.03	0.12	0.1587	0.03	0.13	5.8		
Zirconium Oxide	ZrO_2	60.09	0.15	0.00	0.15	0.1582	0.00	0.16	5.5		
Total solids added			772.82	138.23	634.59	772.99	138.21	634.79		205	
Totals in simulant batch 4A			747313.82	478300.18	269013.64	749172.99	479309.38	269795.39		96775	

APPENDIX C

Batch 1 Analytical Data

Appendix Contents

- Liquid, Solid, and Gas Sample Analyses
- Comparison of ADS Analysis of simulant to theoretical composition, including a discussion of uncertainties
- Lasentec Data

Special Notes:

- An uncertainty analysis for the formulation of the simulant and the analysis of the sample of the simulant collected before precipitation reagents were added. This analysis is included following the analytical results. Uncertainties for other samples should be similar.
- Each Solid Sample was divided into four segments for various dissolutions and analyses except the post-filtration solids which were not subdivided due to their small quantity.
- < values indicate below detection limits.
- The simulant sample that was separated into the 1L liquid and 1S solid samples was actually taken 210 minutes before reagent addition. This sample is considered the "0" time sample for comparison purposes.
- The post-filtration solid sample 172483 was obtained using a coliwasa from the filtrate drum at 1130 hours on 11/20/01, which is 49 days after the filtering was completed at 1508 on 10/2/01. The filtrate was filtered and the solids dried. Analyses performed on this sample included XRD, ICPMS, and ICP-ES.
- SVOC Analysis of Solid Samples was performed on ADS 300169784 through ADS 300169793, which are also identified as 169784 through 169793 in the data pages.
- VOC Gas Analysis was performed on ADS 3-169701 through ADS 3-169704, ADS 3-169600 through ADS 3-169635, and ADS 3-169784 through ADS 3-169793, which are also identified as 169701 through 169704, 169600 through 169635, and 169784 through 169793 in the data sheets.
- The identification of materials by the X-ray Diffraction (XRD) method was performed in accordance with the International Center for Diffraction Data at www.icdd.com using the Powder Diffraction Database of PDF cards.

Batch #1 ANALYTICAL RESULTS												
			Liquid Analysis									
EDL Sample No.			1L	2L	3L	4L	5L	6L	7L	8L	9L	10L
Time after Reagent Add (hrs)			0	0.125	0.25	0.5	1	2	3	4	6	8
ADS Sample No.			169600	169627	169628	169629	169630	169631	169632	169633	169634	169635
Identity	Method	Units										
K	AAK	μg/gm	1620	1349	1322	1061	1293	1282	1649	1261	1262	1256
AlO_2^-		molar	0.0156	0.0168	0.0134	0.0162	0.01	0.015	0.0126	0.0136	0.05	0.05
CO_3^{2-}		molar	0.7032	0.6362	0.5568	0.5752	0.5725	0.5955	0.6288	0.629	0.612	0.5672
Free OH^-		molar	0.036	0.0108	<0.002	0.0141	0.005	0.0182	0.02	0.0234	0.01	0.01
Total OH^-		molar	0.767	0.631	0.625	0.585	0.626	0.627	0.6404	0.6299	0.6292	0.63
Na	AANA	μg/gm	95829	97006	98070	77851	95676	94983	94235	94332	93443	94286
Specific Gravity			1.267	1.245	1.242	1.24	1.245	1.241	1.244	1.246	1.246	1.246
pH			10.2	10.014	10.013	10.016	10.02	10.02	10.02	10.02	10.02	10.02
Total Carbon		μg/ml	33800	29300	27300	27100	27800	28200	28100	28793	26932	28240
TOC		μg/ml	19050	16600	15220	15346	15235	15243	15514	15069	14292	15445
TIC		μg/ml	14700	12600	12740	12780	12660	12900	13050	13106	13334	12800
Acetate	IEC	mg/kg	737	699	684	670	838	792	805	774	773	815
Glycolic Acid	IEC	mg/kg	12857	11846	11888	11765	12537	11703	11504	11425	10890	11715
Citric Acid	IEC	mg/kg	4910	4646	4652	4388	4519	4274	4449	4134	3974	4419
Succinic acid	IEC	mg/kg	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
D_2EHPA	IEC	mg/kg	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Gluconate	IEC	mg/kg	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NTA	IEC	mg/kg	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IDA	IEC	mg/kg	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Formate ($HCOO^-$)	IEC	mg/kg	8453	6309	6684	6235	7923	7129	6882	6851	6466	7081
Fluoride	IC	μg/gm	2880	2286	1926	2341	2075	1733	2417	2300	2066	2376
Formate ($HCOO^-$)	IC	μg/gm	5862	8720	7541	8680	7817	7310	8833	8768	4058	8894
Nitrite (NO_2^-)	IC	μg/gm	35659	31670	27099	32435	29142	24378	33266	32090	26980	32923
Phosphate (PO_4^{3-})	IC	μg/gm	1147	776	645	748	514	585	768	639	722	734
Oxalate ($C_2O_4^{2-}$)	IC	μg/gm	880	1807	1548	1824	1581	1389	1845	1754	1415	1817
Chloride (Cl^-)	IC	μg/gm	1011	1096	935	1109	974	842	1137	1112	900	1139
Nitrate (NO_3^-)	IC	μg/gm	105156	116665	103842	121459	94362	93453	122314	117102	109236	122565
Sulfate (SO_4^{2-})	IC	μg/gm	4477	4287	3701	4375	3961	3353	4531	4333	3968	4546
HEDTA	IPC	mg/l	734	464	438	432	435	547	429	475	426	418
EDTA	IPC	mg/l	2876	2133	2032	2022	2032	2542	2225	2340	2300	1950
Cd	ICP-MS	μg/gm	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Ce	ICP-MS	μg/gm	26.4	6.67	6.14	4.84	5.61	4.93	4.73	4.5	4.3	4.17
Cs	ICP-MS	μg/gm	10.4	9.15	8.89	7.52	10.1	8.59	8.62	8.88	9.16	8.81
La	ICP-MS	μg/gm	23.2	3.34	3.22	2.59	2.84	2.52	2.44	2.43	2.37	2.22
Nd	ICP-MS	μg/gm	43.5	8.84	9.14	6.6	7.09	5.99	6.06	5.4	5.51	4.61
Re	ICP-MS	μg/gm	11	10.2	10.3	8.04	10.1	9.79	9.67	9.8	9.5	9.4
Pb	ICP-MS	μg/gm	201	132	127	98.6	120	103	93.3	83.7	70.4	73.5
Al	ICP-ES	μg/gm	386	592	83	118	223	54	145	131	157	66
B	ICP-ES	μg/gm	56	74	28	21	23	<20	<20	<20	<20	<20
Ba	ICP-ES	μg/gm	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Ca	ICP-ES	μg/gm	129	62	41	38	45	21	21	21	23	23
Cd	ICP-ES	μg/gm	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Cr	ICP-ES	μg/gm	93	73	74	62	77	67	68	67	67	67
Cu	ICP-ES	μg/gm	22	89	131	113	531	26	43	53	143	106
Fe	ICP-ES	μg/gm	1005	464	354	449	445	273	291	262	287	258
K	ICP-ES	μg/gm	1420	1300	1300	1060	1260	1240	1300	1220	1280	1270
Mg	ICP-ES	μg/gm	51	16	13	15	18	11	12	13	12	12
Mn	ICP-ES	μg/gm	294	281	302	254	324	339	348	363	379	389
Na	ICP-ES	μg/gm	110000	96600	97000	76400	94900	92600	92400	93900	92600	94000
Ni	ICP-ES	μg/gm	296	301	308	324	851	262	272	278	333	308
P	ICP-ES	μg/gm	205	124	133	105	132	126	125	125	120	118
Pb	ICP-ES	μg/gm	204	125	124	93	120	95	87	94	70	68
Si	ICP-ES	μg/gm	47	34	18	39	33	<10	<10	<10	<10	21
Sr	ICP-ES	μg/gm	5	19.6	13	7.3	8.3	5.3	5	5.3	5	4
Zr	ICP-ES	μg/gm	33	26	26	21	26	25	24	25	25	25
S	ICP-ES	μg/gm	1650	1400	1450	1190	1390	1380	1390	1390	1390	1400
Note: N/A means method not available.												

Batch #1 ANALYTICAL RESULTS													
			Solids Analysis										
EDL Sample No.			1S	2S	3S	4S	5S	6S	7S	8S	9S	10S	Post-Filtration
Time after Reagent Add (hrs)			0	0.125	0.25	0.5	1	2	3	4	6	8	1318
Identity	Units	Method											
Quantity collected	grams		3.98	39.2	39.8	40.7	38.0	42.0	40.6	41.4	43.3	34.4	
ADS Sample No.			169764	169765	169766	169767	169768	169769	169770	169771	169772	169773	172483
Pretreatment: 0.25 gm of solids disolved in aquaregia (9 ml HCl + 3 ml HNO_3) then diluted with water to 250 ml													
Cd	μg/gm	ICP-MS	<1	<1	<1	<1	<1	<1	<1	<1	0.54	1.32	<15
La	μg/gm	ICP-MS	528	516	551	507	587	530	533	548	549	600	768
Ce	μg/gm	ICP-MS	843	515	544	527	588	550	549	567	583	627	946
Nd	μg/gm	ICP-MS	1720	956	1030	966	1110	1020	1040	1060	1080	1170	1510
Re	μg/gm	ICP-MS	2.1	14	12.5	12.8	11	14.4	12.2	14.1	14	11.8	26.2
Pb	μg/gm	ICP-MS	413	1530	1650	1730	2090	2230	2360	2690	2840	2940	2850
Al	μg/gm	ICP-ES	30100	3930	4340	3660	4230	3900	3800	4100	4230	4590	3200
B	μg/gm	ICP-ES	910	2110	563	376	334	298	608	215	<205	603	59
Ba	μg/gm	ICP-ES	21	1090	1150	1060	1200	1070	1070	1080	1110	1190	850
Ca	μg/gm	ICP-ES	87900	7700	8350	7500	8520	7650	8110	8050	8510	8760	7170
Cd	μg/gm	ICP-ES	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	<4.0
Cr	μg/gm	ICP-ES	925	389	409	381	427	457	454	521	554	550	458
Fe	μg/gm	ICP-ES	48600	16900	18200	17200	19800	18300	18900	19300	20000	21500	17300
Mg	μg/gm	ICP-ES	2880	954	1010	930	1060	963	976	1020	1050	1120	975
Mn	μg/gm	ICP-ES	26000	60200	62400	573000	64100	56800	56600	57000	58300	61200	35000
Na	μg/gm	ICP-ES	165000	174000	163000	153000	140000	163000	156000	169000	162000	146000	180000
Ni	μg/gm	ICP-ES	<70	328	282	278	221	306	281	340	294	250	354
P	μg/gm	ICP-ES	1140	2040	1960	1650	2390	2610	2350	2020	2600	2080	1960
Pb	μg/gm	ICP-ES	<700	1367	1651	1694	1913	1947	2020	2603	2664	2745	2840
Si	μg/gm	ICP-ES	2250	321	313	403	407	218	326	364	437	496	251
Sr	μg/gm	ICP-ES	743	155000	163000	151000	170000	153000	153000	155000	159000	170000	129000
Zr	μg/gm	ICP-ES	378	150	144	140	153	142	142	134	152	139	<10
K	μg/gm	ICP-ES	<500	2690	2080	2550	1870	1990	1900	1790	2040	1610	2620
S	μg/gm	ICP-ES	1190	2780	3090	2060	1580	2220	1830	2350	2330	1860	3270
Nd	μg/gm	ICP-ES	1071	683	1014	723	765	737	757	827	844	931	1570
Cu	μg/gm	ICP-ES	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	27
Zn	μg/gm	ICP-ES											116
ADS Sample No.			169774	169775	169776	169777	169778	169779	169780	169781	169782	169783	
Pretreatment: 0.25 gram of solids fused with 1.5 gm Na_2O_2 + 1.0 gm NaOH, disolved in 25 ml of HCL, and diluted with water to 250 ml													
Al	μg/gm	ICP-ES	28300	8080	7860	8710	7530	7630	7840	8760	7690	8080	
B	μg/gm	ICP-ES	247	<250	<250	<250	<250	<250	<250	<250	<250	<250	
Ba	μg/gm	ICP-ES	50	1160	1140	1160	1110	1150	1120	1220	1100	1180	
Ca	μg/gm	ICP-ES	86100	9270	9250	9550	9890	11700	9560	10200	10400	11100	
Cd	μg/gm	ICP-ES	<15	<20	<20	<20	<20	<20	<20	<20	<20	<20	
Cr	μg/gm	ICP-ES	2161	718	819	738	761	820	763	897	818	876	
Fe	μg/gm	ICP-ES	26600	17300	18700	20600	18800	18700	18900	21500	18200	20600	
Mg	μg/gm	ICP-ES	1430	975	998	1060	1050	1070	1010	1130	1140	1100	
Mn	μg/gm	ICP-ES	16800	62000	60100	58900	56000	59000	55700	60900	52500	58100	
Ni	μg/gm	ICP-ES	270	321	383	300	376	350	381	311	378	343	
P	μg/gm	ICP-ES	681	1690	1550	1790	1740	1750	2050	2240	2090	2060	
Si	μg/gm	ICP-ES	7090	1360	1060	1560	1030	1010	1530	1160	920	1060	
Sr	μg/gm	ICP-ES	810	165000	163000	165000	166000	179000	158000	170000	163000	170000	
K	μg/gm	ICP-ES	1460	3480	3960	3130	3370	3190	3260	3940	3970	3640	
S	μg/gm	ICP-ES	1950	2030	1910	1980	2190	2080	2110	1980	2090	2050	
Nd	μg/gm	ICP-ES	778	897	879	886	880	1128	925	984	892	1102	
ADS Sample No.			169754	169755	169756	169757	169758	169759	169760	169761	169762	169763	
Pretreatment: 0.25 gram of solids fused with 1.5 gm Na_2O_2 + 1.0 gm NaOH, then disolved by and diluted with water to 250 ml													
Fluoride	μg/ml	ICA	<198	818	1059	911	981	834	859	779	764	768	
Formate ($HCOO^-$)	μg/ml	ICA	<989	<974	<1001	<963	<975	<995	<989	<957	<968	<997	
Nitrite (NO_2^-)	μg/ml	ICA	<989	<974	<1001	<963	<975	<995	<989	<957	<968	<997	
Phosphate (PO_4^{3-})	μg/ml	ICA	<989	2344	2544	2562	3171	2860	2965	3023	3014	3271	
Oxalate ($C_2O_4^{2-}$)	μg/ml	ICA	<989	<974	<1001	<963	<975	<995	<989	<957	<968	<997	
Chloride (Cl^-)	μg/ml	ICA	989	5741	5734	2398	1909	3266	2000	2485	2278	2087	
Nitrate (NO_3^-)	μg/ml	ICA	2966	137977	124417	114634	108201	173607	126978	146013	153065	147666	
Sulfate (SO_4^{2-})	μg/ml	ICA	2966	7776	6943	7012	5646	6697	7611	7181	7803	6364	

Batch #1 ANALYTICAL RESULTS													
			Solids Analysis										
EDL Sample No.			1S	2S	3S	4S	5S	6S	7S	8S	9S	10S	Post-Filtration
Time after Reagent Add (hrs)			0	0.125	0.25	0.5	1	2	3	4	6	8	1318
Identity	Units	Method											
ADS Sample No.			169784	169785	169786	169787	169788	169789	168790	169791	169792	169793	172483
Solids microwave dried													
% moisture			3.377	2.21	3.7	6.004	6.452	2.71	2.96	2.03	6.95	4.29	
Total Carbon	µg/ml		39996	17400	16100	15180	14000	16720	16840	17240	17200	16800	
TOC	µg/ml		16362	6780	6720	6240	5560	7080	6960	6980	7000	6340	
TIC	µg/ml		23634	10720	9300	8900	8400	9700	9880	10260	10160	10400	
Fluoride	µg/ml		147	802	1000	854	704	1152	1033	990	1757	922	
Formate ($HCOO^-$)	µg/ml		170	14131	12072	11616	11507	14215	14511	13380	18223	14805	
Nitrite (NO_2^-)	µg/ml		169	29979	30918	30848	27650	34941	33065	34818	39934	30998	
Phosphate (PO_4^{3-})	µg/ml		81	340	847	677	542	162	941	433	689	99	
Oxalate ($C_2O_4^{2-}$)	µg/ml		31269	13950	10168	9337	9347	12691	12979	13965	17278	14276	
Chloride (Cl^-)	µg/ml		5533	2069	1805	1989	1798	1621	2033	2579	2394	2071	
Nitrate (NO_3^-)	µg/ml		897	85751	87859	85375	88470	83389	81381	81950	68963	87160	
Sulfate (SO_4^{2-})	µg/ml		278	6026	5230	5666	5408	6338	7002	6622	10251	6581	
Al_2O_3(corundrum)		XRD	74-1081										
MnO_2(pyrolusite)		XRD	24-0735										
Fe_2O_3(Hermatite)		XRD	72-0469										
C_2CaO_4!H_2O(Whewelite)		XRD	20-0231										
$CaCO_3$(calcite)		XRD	86-0174										
SiO_2(Quartz)		XRD	46-1045										83-2465
$Mn(SO_3)H_2O$(Mang Sulf Hyd)		XRD	82-0764										
$C_2Na_2O_4$(Natroxalate)		XRD	20-1149										
$NaNO_3$(Sodium Nitrate)		XRD		79-2056	79-2056	79-2056	79-2056	79-2056	79-2056	79-2056	79-2056	79-2056	36-1474
$SrCO_3$(Strontianite)		XRD		71-2393	71-2393	71-2393	71-2393	71-2393	71-2393	71-2393	71-2393	71-2393	71-2393
$Na_4Sr(SiO_3)_3$-Na,Sr, Silicate		XRD		76-0416	76-0416	76-0416	76-0416	76-0416	76-0416	76-0416	76-0416	76-0416	76-0416
$(Ca_{0.8}Sr_{0.2})MnO_3$-Ca,Sr,Mn		XRD		50-1747	50-1747	50-1747	50-1747	50-1747	50-1747	50-1747	50-1747	50-1747	

SRT-ADS-02-0031 SVOC Analysis of Solid Samples

Results

Eleven samples were submitted for semivolatile organic compound (SVOC) analysis. No SVOC analytes were detected and the method detection limit (MDL) for the samples in this study was 10 mg/L.

Experimental

The samples were extracted with methylene chloride and analyzed.

Gas Chromatography / Mass Spectrometry (GC/MS) analysis was employed to identify organic compounds in the sample. Analysis were carried out in building 773-A, laboratory B-123. It should be noted that ADS is not certified by DHEC for NPDES discharge compliance monitoring. Analytical separations were carried out on a Hewlett Packard 6890 gas chromatograph, equipped with a 30 m DB-5 column, with 0.25 mm diameter and 0.25 um film thickness. Quantitation was performed using a Hewlett Packard 5973 mass selective detector. The mass spectrometer tuning was confirmed within 24 hours prior to each measurement using perfluorotributylamine.

	Batch #1 Gas Analysis			
compound (%)	1G	2G	3G	4G
ADS Sample No.	169701	169702	169703	169704
H2	0	0	0	0
O2	20.8	20.7	20.6	20.6
N2	79	79.4	77.8	78.4

GC/MS Analysis Results-VOC

solid, liquid, gas samples no detectable VOC analytes

Results

Ten solid, ten liquid, and four gas samples were submitted for volatile organic compounds (VOC) analysis.

The samples did not contain any detectable VOC analytes, and the limits of detection for this study are tabulated below.

Sample Matrix	MDL	units
Gas	0.2	ppmv
Liquid (Aqueous)	1	ug/L
Solid	10	ug/kg

Experimental

Solid, liquid, and gas samples were analyzed using purge and trap Gas Chromatography / Mass Spectrometry (GC/MS).
GC/MS analysis was employed to identify organic compounds in the samples. Analyses were carried out in building 773-A, laboratory B-159. It should be noted that ADS is not certified by DHEC for NPDES discharge compliance monitoring.
Samples were concentrated using a Tekmar 2016 Purge and Trap concentrator, using a three stage (10 cm Carbopack B / 6 cm Carboxen 1000 / 1 cm Carboxen 1001) trap. Analytical separations were carried out on a Hewlett Packard 6890 gas chromatograph, equipped with a 20 m DB-624 column, with 0.18 mm diameter and 1.0 um film thickness.
Quantification was performed using a Hewlett Packard 5973 mass selective detector.
The mass spectrometer tuning was confirmed within 24 hours prior to each measurement using perfluorotributylamine.
Some VOC samples for this study were analyzed on the following instrument.
Volatile organic analyses were performed by Gas Chromatography - Mass Spectrometry (GC-MS), using the ADS method 2656 (Contract Laboratory Program SOW 7-93 for Volatile Organics).
Samples were concentrated using an OI Analytical model 4460A Dynamic Headspace concentrator (Purge and Trap), using a three stage (10 cm Carbopack B / 6 cm Carboxen 1000 / 1 cm Carboxen 1001) trap.
Separation was performed with a Hewlett Packard 5890 series II gas chromatograph on a 105m x 0.32 mm VOCOL glass capillary column with 3 um film thickness. Quantitation was performed with a Hewlett Packard model 5971 quadrupole mass spectrometer. Internal standard and recovery surrogate compounds were added as specified in the Contract Laboratory Program for volatile organics (SOW 7-93).
The mass spectrometer tuning was confirmed within 12 hours prior to each measurement using 4-bromofluorobenzene.
Tuning verification was performed against CLP tuning requirements, specifically to optimize CLP requirements for high mass sensitivity.
50/95 ratios which are between 8%-15%, may require appropriate flagging if used for other purposes.

Quantifying the Measurement Uncertainty with the RPP-WTP Precipitation Task

		AN107+Entrained Solids according to Recipe				AN107+ Entrained Soilds according to Sample 1L (Taken before precipitation - Appendix A, Col. 1L)											
		Liquid	Solids	Combined		Liquid portion of sample			Solid Portion of sample			Combined					
Item No.	Element	Based on total mixture	Based on total mixture	(F) Total in mixture	uncertainty (2)	ADS analysis	Based on total mixture	uncertainty (3)	ADS analysis	Based on total mixture	uncertainty (4)	(Q) Total in mixture	uncertainty	Difference (Q) - (F) (5)	Uncertainty in (Q) - (F)	Ratio Q/F	Uncertainty in Q/F
		µg/gm	µg/gm	ppm	ppm	µg/gm	ppm	ppm	µg/gm	ppm	ppm	ppm	ppm	ppm	ppm		
1	Al	323.0	146.9	469.9	33.6	386	386	38.8	30100	95.4	13.5	481.4	83.5	11.5	90.0	1.02	18.8%
2	B	17.6		17.6	1.2	56	56	5.6	910	2.9	0.4	58.9	10.2	41.3	10.3	3.35	18.7%
3	Ca	296.8	1.8	298.6	21.3	129	129	13.0	87900	278.6	39.4	407.6	70.7	109.0	73.9	1.37	18.8%
4	Ce	26.5		26.5	1.9	26.4	26	2.7	843	2.7	0.4	29.1	5.0	2.6	5.4	1.10	18.7%
5	Cr	88.4	6.5	94.9	6.8	93	93	27.9	925	2.9	0.9	95.9	41.8	1.1	42.4	1.01	44.2%
6	Cs	9.3		9.3	0.7	8	8	0.8	0	0.0	0.0	8.0	0.8	-1.3	1.0	0.86	12.3%
7	Cu	15.1		15.1	1.1	22	22	6.6	0	0.0	0.0	22.0	6.6	6.9	6.7	1.46	30.8%
8	EDTA	3135.7		3135.7	221.7	2290.61	2291	779.1	0	0.0	0.0	2290.6	779.1	-845.1	810.1	0.73	34.7%
9	HEDTA	1086.2		1086.2	76.8	584.60	585	58.8	0	0.0	0.0	584.6	58.8	-501.6	96.7	0.54	12.3%
10	Fe	848.3	83.0	931.3	66.5	1005	1005	101.0	48600	154.1	48.7	1159.1	384.6	227.7	390.3	1.24	33.9%
11	K	909.0		909.0	64.9	1420	1420	426.2	0	0.0	0.0	1420.0	426.2	511.0	431.2	1.56	30.9%
12	La	22.8		22.8	1.6	23.2	23	2.3	528	1.7	0.2	24.9	4.3	2.0	4.6	1.09	18.7%
13	Mg	12.5		12.5	0.9	51	51	15.3	2880	9.1	2.9	60.1	26.2	47.6	26.2	4.79	44.2%
14	Mn	282.6	97.0	379.6	27.1	294	294	29.5	26000	82.4	11.7	376.4	65.3	-3.2	70.7	0.99	18.8%
15	Na	104115.2		104115.2	7362.1	110000	110000	11054.9	165000	523.0	165.4	110523.0	36673.0	6407.9	37404.7	1.06	33.9%
16	Nd	48.1		48.1	3.4	43.5	44	4.4	1720	5.5	0.8	49.0	8.5	0.8	9.1	1.02	18.7%
17	Ni	266.1		266.1	18.8	296	296	29.7	0	0.0	0.0	296.0	29.7	29.9	35.2	1.11	12.3%
18	P	458.0	0.7	458.7	33.1	205	205	20.6	1140	3.6	0.5	208.6	36.2	-250.1	49.0	0.45	18.8%
19	Pb	194.8		194.8	13.8	201	201	20.2	413	1.3	0.2	202.3	35.1	7.5	37.7	1.04	18.7%
20	Re	9.4		9.4	0.7	11	11	1.1	2.1	0.0	0.0	11.0	1.9	1.6	2.0	1.17	18.7%
21	S	1403.0		1403.0	100.2	1650	1650	165.8	1190	3.8	0.5	1653.8	286.9	250.7	303.9	1.18	18.8%
22	Si		12.1	12.1	0.9	47	47	4.7	2250	7.1	2.3	54.1	18.0	42.0	18.0	4.46	33.9%
23	Sr	3.3		3.3	0.2	5	5	1.5	743	2.4	0.7	7.4	3.2	4.0	3.2	2.22	44.2%
24	Zr	35.1		35.1	2.5	33	33	3.3	378	1.2	0.2	34.2	5.9	-0.9	6.4	0.97	18.7%
		Total	Total	Total	Total		Total	Total		Total	Total	Total	Total	Average	Average	Average	Average
		113606.8	348.16	113955.0	8061.6		118880	12813.9		1177.7	288.7	120058.0	39061.8	254.3	1663.7	1.49	24.7%

(1) Each element comes from 1 or more compounds therefore for Aluminum:
3646.89 grams of $Al(NO_3)_3.9H_2O$ or 3646.89g/375.13g/g-mole = 9.7217 moles x 26.9815 g/mole Al = 323.1 grams
225.3 grams of Al_2O_3 or (2 x 225.3g) / 101.96g/g-mole = 4.4194 moles x 26.9815 = 146.9 grams
for a total of 323.1 + 146.9 = 469.9 g of Al per 811974 g simulant for a concentration of 469.90 ppm

(2) Since each element can come from several compounds the uncertainty will be a combination of all measured quantities for instance you have:
Let's say your measurement uncertainties were for Al: 1% on weight therefore you have 1% on the Al nitrate,
1% on the Al oxide, and 1% on the overall (2), giving a total uncertainty of [(1%)^2+(1%)^2+(1%)^2]^(1/2) = [3]^(1/2)x1% = 1.73%
or 340.64 x 0.017 = 5.79 ppm

However, if your total weight was not measured at once and your stated overall just adding up all 49 compounds then the overall uncertainty would be [49]^(1/2) x 1% = 7% which would make your overall uncertainty:
[(1%)^2+(1%)^2+(7%)^2]^(1/2) = [3]^(1/2)x1% = 7.1% >> or 340.64 x 0.071 = 24.19 ppm

(3) This is an ADS generated number. For this example it is set at 10% unless close to detection limit when 30% will be used per Frank Pennebaker.

(4) This assumed uncertainty include that of the ADS concentration (5%), the weight of the solids in the liter sample (1%), that the sample was one liter (5%), that the total volume of batch was 646.702 liters (5%), and that total mass batch was 811974 grams(7%)

(5) Differences in (F) and (Q) totals are due to contaminants in the compounds added. Therefore, the (Q) data from ADS will be used for DF calculations, except for strontium which will be based on the recipe.

Individual Measurement Uncertainties	Percent
Small Weights	1
Large Weights	1
Combined Wgts	7
Small Volumes	5
Large Volumes	5
ADS_IPC_Liquid	34
ADS_icpes_Liquid	10
ADS close to Det	30
ADS_icpes_Solid	10
Density Corr.	1

Lasentec Chord Length Data for Pilot-Scale Precipitation Batch #1

Post Filtration Samples

Hanford AN-107 simulant samples were received from Engineering Development Laboratory personnel for analysis of post filtration solids. The samples were precipitate filtrate samples which were isolated at various times after the completion of precipitate reagent additions (on 9-26-01 at 13:39 hours) as indicated in Table C-1 below. Each sample had been filtered through a 0.1 micron Mott Crossflow Filter to yield approximately 1 L of filtrate. The samples were stored in 1L wide-mouth, amber polypropylene bottles to minimize interactions with light during storage. This bottle type allowed for Lasentec chord length analysis without removing the sample from the storage container. Samples were analyzed with the Lasentec within 24 hours of receipt to determine whether any solids were present.

The Lasentec FBRM is a laser-based technique, which utilizes back-scattered signal from particles within the detector measurement zone to obtain chord length data for a population of particles. The FBRM is a highly sensitive technique due to the fact that it measures backscattered laser intensity from individual particles within the sample. In addition, the method requires no sample preparation and is suitable for in-process analysis. These are significant advantages over traditional methods for the analysis of suspended solids in liquid media. The FBRM method requires that the particles be passed across the probe surface. This is generally achieved by placing the probe within a flowing liquid stream or (in the case of individual samples) by stirring the liquid using an appropriately designed and positioned impeller blade. A particle chord length is defined as the diameter of the particle as it is presented to the detector. For a given non-spherical particle, the particle may be presented to the detector in a number of orientations and a number of unique chords may be measured. Since the AN-107 simulant composition is complex, post-filtration solids may contain a mixture of particles with different compositions and morphologies (shapes). This adds to the complexity of the measured chord length distribution. In addition, as particle counts increase, the FBRM response may not be linear and the data cannot be considered to be highly quantitative unless suitable standards can be prepared and a calibration curve generated. Nonetheless, general comparisons of particle counts can be made between samples of the same type.

Table C-1 AN-107 Filtrate Sample Isolation Times

Sample ID	Sample Collection Date/Time	Reaction Time Before Filtration (hr)
PF1-1	9-26-01/21:08	7.5
PF1-2	9-26-01/21:08	7.5
PF1-3	9-28-01/12:53	47.2
PF1-4	10-1-01/15:43	122
PF1-5	10-2-01/15:08	145

Figures C-1 and C-2 show the chord length data obtained for the samples from pilot scale precipitation batch #1 within 24 hours after filtration. Samples PF1-1 and –2 were duplicate samples isolated only 7.5 hours after the initiation of precipitation. The remaining samples were isolated after significantly longer reaction times (from 2-6 days) and were not collected in duplicate. As indicated in Table C-2 and Figure C-2, samples PF-1 and –2 contained significantly greater particle counts than any of the remaining samples. Note that the counts per second provided in Table C-2 cannot be directly related to weight % solids in the samples, since this measurement was not conducted. Visible solids could not be observed in either of these samples and it is unlikely that the total mass of solid material was high enough to be isolated and measured accurately. As indicated in Figure C-1, the chord length distributions obtained for the PF-1 and –2 samples were very similar. The mean chord lengths measured for the two samples were 6.6 and 6.8 microns, respectively (Table C-2). Extremely low particle counts were measured for samples PF1-3 and –4, although particles were present with the chord length distributions indicated in Figure C-1. The mean chord length was considerably larger and the distribution more broad for the PF1-3 and –4 samples than was observed for the –1 and –2 samples. Sample PF1-5 contained no measurable particles. The instrumental background signal is typically around 15 counts per second.

Table C-2 Chord Length Data Obtained Within 24 Hours After Filtration

Sample	Total Counts/sec	Mean Chord Length (μm)	Measurement Time After Filtration (hr)
PF1-1	3846	6.6	18
PF1-2	3160	6.8	18
PF1-3	55	75	21
PF1-4	38	41	24
PF1-5	15	90	1.1

Figure C-1 Pilot Scale Run #1 Chord Length Data Within 24 Hours After Filtration (Chord Length vs. %/Channel)

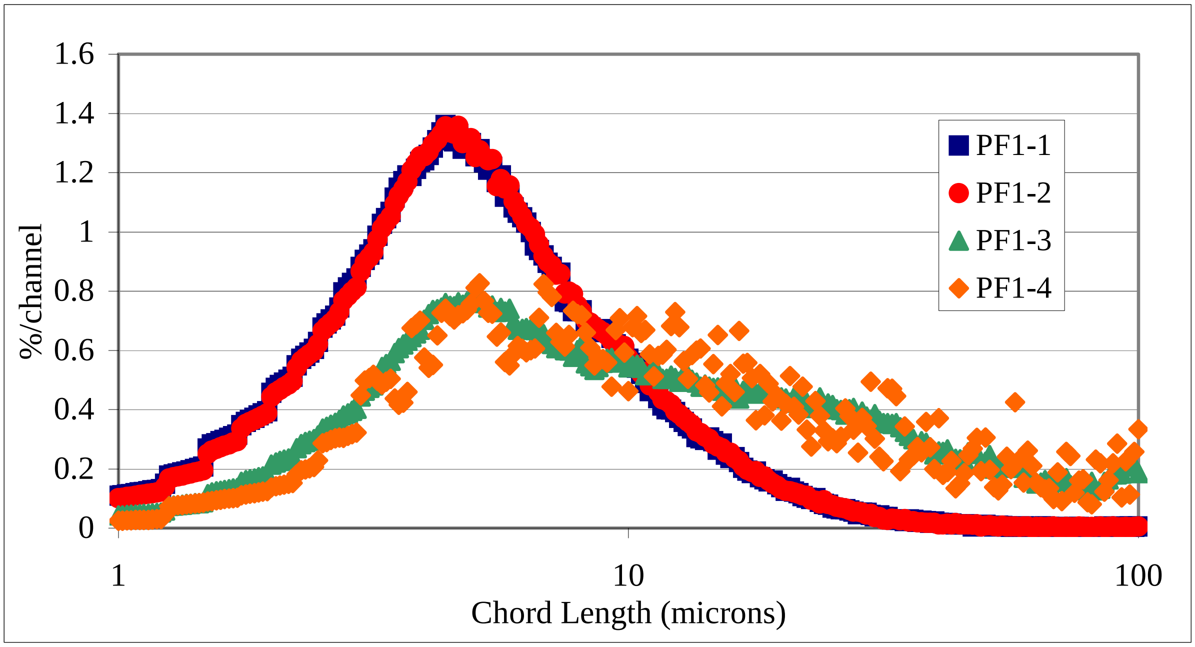
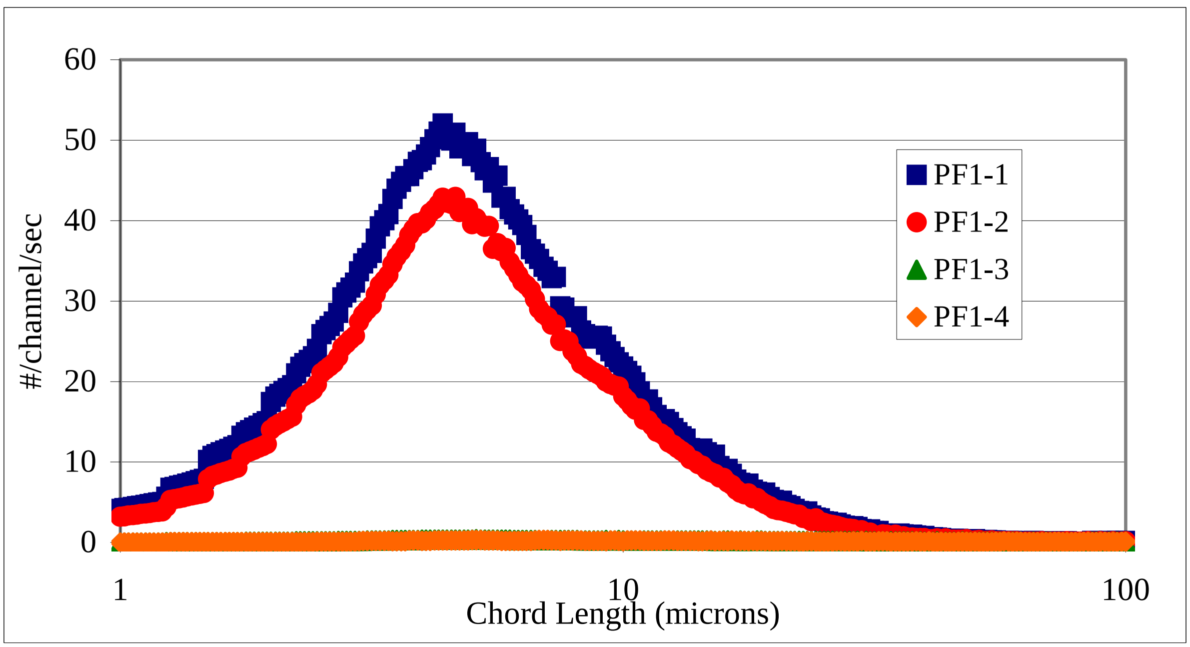


Figure C-2 Pilot Scale Run #1 Chord Length Data Within 24 Hours After Filtration (Chord Length vs. #/channel/sec)



The samples were stored after analysis for over 5 months at ambient temperature in the amber bottles. The air headspace above the samples was <10% of the total volume. Figures C-3 and C-4 and Table C-3 provide the chord length data for the samples after storage. The samples were all analyzed on 3-6-02. Samples PF1-1 and –2 contained films of solids on the container bottoms and sides. Approximately 75% of the solids were removed from the container walls by shaking the bottles. Results for the duplicate samples (-1 and –2) were similar. The mean chord lengths for the two samples (11 µm) were shifted to slightly larger values than the mean values reported above for these samples just after filtration. The shift toward larger chord lengths presumably results from aggregation of particles during the formation of the film. The distribution was also considerably more broad for the samples after storage. The PF1-3 sample contained some solids on the container bottom after storage which were easily suspended. The chord length distribution was sharper and the mean chord length value was much smaller as compared to the distribution immediately after filtration. Samples PF1-4 and –5 contained no measurable amounts of solids. The small amount of solids that was present in the PF1-4 sample immediately after filtration apparently either redissolved over time or formed a thin film on the container walls that was not visually observable.

Table C-3 Chord Length Data Obtained After Storage for Several Months

Sample	Total Counts/sec	Mean Chord Length (µm)
PF1-1	1637	11
PF1-2	1353	11
PF1-3	204	10
PF1-4	15	57
PF1-5	7.9	92

Figure C-3 Pilot Scale Run #1 Chord Length Data After Storage (Chord Length vs. %/channel)

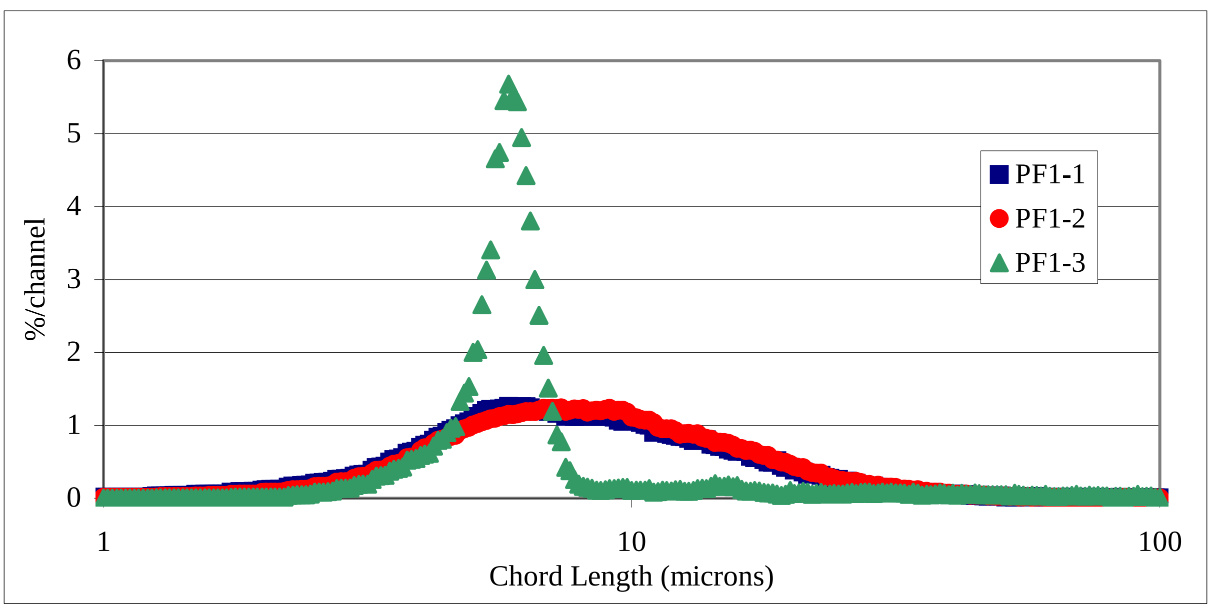
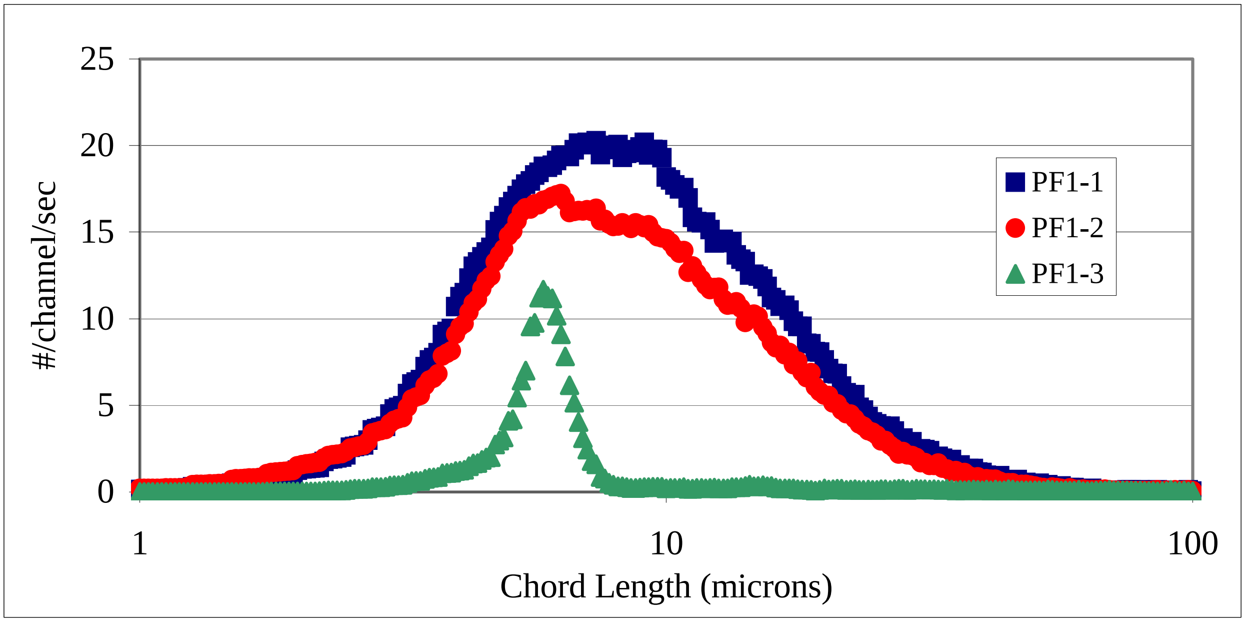


Figure C-4 Pilot Scale Run #1 Chord Length Data After Storage (Chord Length vs. #/channel/sec)



APPENDIX D

Batch 2 Analytical Data

Appendix Contents

- Liquid, Solid, and Gas Sample Analyses
- Lasentec Data

Special Notes:

- Each Solid Sample was divided into four segments for various dissolutions and analyses except the post-filtration solids which were not subdivided due to their small quantity.
- < values indicate below detection limits.
- The simulant samples 0L and 0S are actually the analysis of the simulant sample collected during the Batch #1 experiment prior to adding any reagents. The mixing procedure for Batch #1 and #2 were identical, so an additional sample was not thought to be necessary.
- The simulant sample that was separated into the 1L liquid and 1S solid samples was actually taken about an hour minutes before reagent addition. This sample is considered the "0" time sample for comparison purposes.
- The post-filtration solid sample 172483 was obtained using a coliwasa from the filtrate drum on 11/20/01, which is 26 days after the filtering was completed on 10/25/01. The filtrate was filtered and the solids dried. Analyses performed on this sample included XRD, ICPMS, and ICP-ES.
- SVOC Analysis of Solid Samples was performed on ADS 300170474 through ADS 300170483, which are also identified as 170474 through 1170483 in the data pages.
- VOC Gas Analysis was performed on ADS 3-170441 through ADS 3-170454 and ADS 3-170474 through ADS 3-170483, which are also identified as 170441 through 170454, and 170474 through 170483 in the data sheets.
- The identification of materials by the X-ray Diffraction (XRD) method was performed in accordance with the International Center for Diffraction Data at www.icdd.com using the Powder Diffraction Database of PDF cards.

BATCH #2 ANALYTICAL RESULTS														
			Liquid Analysis											
EDL Sample No.			0L	1L	2L	3L	4L	5L	6L	7L	8L	9L	10L	Post-Filtration
Time after Reagent Add (hrs)			0	0	0.125	0.25	0.5	1	2	3	4	6	8	2184
ADS Sample No.			169600	170445	170446	170447	170448	170449	170450	170451	170452	170453	170454	(3)
Identity	Method	Units	(1)	(2)										
K	AAK	µg/gm	1620	1318	1188	1159	1172	1120	1152	1157	1181	1219	1168	
AlO_2^-		molar	0.0156	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
CO_3^{2-}		molar	0.7032	0.8585	0.6668	0.6622	0.6808	0.6465	0.6605	0.6602	0.675	0.695	0.6488	
Free OH^-		molar	0.036	0.7545	0.646	0.636	0.651	0.627	0.658	0.643	0.65	0.661	0.623	
Total OH^-		molar	0.767	1.681	1.408	1.4	1.397	1.359	1.36	1.38	1.405	1.427	1.419	
Na	AANA	µg/gm	95829	110796	100175	98536	87585	84000	90439	89766	92288	98193	90176	
Specific Gravity			1.267	1.280	1.260	1.260	1.260	1.260	1.260	1.260	1.270	1.280	1.260	1.280
pH			10.2	12.34	12.38	12.38	12.32	12.37	12.32	12.31	12.29	12.27	12.28	
Total Carbon		µg/ml	33800	25400	21600	21400	20100	22000	21800	22000	23000	24200	22800	
TOC		µg/ml	19050	14780	12980	12540	12340	12980	12700	12860	13480	13980	13320	
TIC		µg/ml	14700	10400	8720	8900	8740	9000	9120	9200	9440	10160	9480	
Acetate	IEC	mg/kg	737	744	693	660	605	583	615	601	620	610	596	
Glycolic Acid	IEC	mg/kg	12857	12017	9941	10786	9097	9315	9124	9600	9836	9980	9660	
Citric Acid	IEC	mg/kg	4910	3498	4545	4235	4067	4076	4127	4013	4253	4390	4181	
Succinic acid	IEC	mg/kg	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
D_2EHPA	IEC	mg/kg	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Gluconate	IEC	mg/kg	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
NTA	IEC	mg/kg	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
IDA	IEC	mg/kg	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Fluoride	IC	µg/gm	2880	2108	1731	1708	1718	1722	1736	1727	1750	1782	1712	
Formate ($HCOO^-$)	IC	µg/gm	5862	4807	4525	4449	4312	4418	4481	4403	4475	4607	4336	
Nitrite (NO_2^-)	IC	µg/gm	35659	25968	23825	23260	23118	23464	23555	23299	24071	24589	23392	
Phosphate (PO_4^{3-})	IC	µg/gm	1147	1222	1012	1012	938	914	886	858	914	958	890	
Oxalate ($C_2O_4^{2-}$)	IC	µg/gm	880	533	1094	1174	1122	1079	1179	117	1085	833	1055	
Chloride (Cl^-)	IC	µg/gm	1011	913	830	820	805	818	822	811	836	864	809	
Nitrate (NO_3^-)	IC	µg/gm	105156	96682	100977	99283	98630	100254	89988	94617	98146	103836	96392	
Sulfate (SO_4^{2-})	IC	µg/gm	4477	4308	3906	3852	3808	3834	3867	3806	3902	4038	3775	
HEDTA	IPC	mg/l	734	420	400	425	600	425	450	450	450	475	425	
EDTA	IPC	mg/l	2876	2158	2225	2200	2525	2450	2125	2175	2275	2275	2075	
Ce	ICP-MS	µg/gm	26.4	24.6	3.17	2.99	2.86	2.63	2.45	2.43	2.33	1.95	2.01	1.05
Cs	ICP-MS	µg/gm	10.40	10.10	8.58	8.52	13.00	8.73	8.06	8.12	8.30	8.67	8.38	
La	ICP-MS	µg/gm	23.2	22.4	2.18	2.02	2.02	1.84	1.82	1.82	1.74	1.58	1.61	0.81
Nd	ICP-MS	µg/gm	43.5	44.3	6.15	5.85	5.67	5.12	5.1	5.31	4.85	4.48	4.59	2.95
Re	ICP-MS	µg/gm	11	9.18	8.56	8.21	8.36	7.83	8.2	8.17	8.31	8.51	8.11	
Pb	ICP-MS	µg/gm	201	175	49.6	47.4	47.7	44	45.6	45.8	44.9	45.8	44	
Al	ICP-ES	µg/gm	386	196	294	214	204	180	178	160	167	170	199	173
B	ICP-ES	µg/gm	56	<20	<20	<20	<20	<20	<20	<20	<20	33	111	27
Ba	ICP-ES	µg/gm	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	0.12
Ca	ICP-ES	µg/gm	129	303	161	159	164	155	153	153	154	160	152	214
Cd	ICP-ES	µg/gm	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<0.01
Cr	ICP-ES	µg/gm	93	78	63	61	63	60	60	62	60	59	63	60
Cu	ICP-ES	µg/gm	22	68	129	152	111	117	16	<10	<10	17	53	12
Fe	ICP-ES	µg/gm	1005	754	100	98	126	93	78	95	80	80	100	50
K	ICP-ES	µg/gm	1420	1240	1160	1120	1180	1110	1150	1170	1150	1180	1130	1992
Mg	ICP-ES	µg/gm	51	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	0.38
Mn	ICP-ES	µg/gm	294	262	82	74	85	84	89	101	94	92	101	18
Mo	ICP-ES	µg/gm												15
Na	ICP-ES	µg/gm	110000	118000	105000	105000	108000	102000	105000	106000	106000	108000	106000	90625
Ni	ICP-ES	µg/gm	296	281	300	304	284	270	253	235	240	248	258	209
P	ICP-ES	µg/gm	205	197	175	158	167	155	170	168	176	182	180	192
Pb	ICP-ES	µg/gm	204	187	<80	<80	<80	<80	<80	<80	<80	<80	<80	35
Si	ICP-ES	µg/gm	47	38	26	23	27	22	<20	<20	<20	<20	<20	15
Sr	ICP-ES	µg/gm	5	4.2	174	172	173	164	156	158	144	110	110	145
Zn	ICP-ES	µg/gm												19.0
Zr	ICP-ES	µg/gm	33	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	4.2
S	ICP-ES	µg/gm	1650	1720	1730	1660	1650	1580	1640	1780	1730	1900	1790	1383
Note (1)	Sample 0L is before caustic addition and is actually the analysis of sample 1L collected during Batch #1.													
(2)	Sample 1L was taken after caustic addition but prior to other reagent additions.													
(3)	Mobile Lab Sample RPP-WP-PREC2-FILTRATE collected from filtrate drum on Jan 22, 2002 (91 days after precipitation). The method of analysis is ICP-ES in all cases.													
N/A	Method not available.													

BATCH #2 ANALYTICAL RESULTS														
			Solids Analysis											
EDL Sample No.			0S	1S	2S	3S	4S	5S	6S	7S	8S	9S	10S	Post-Filtration
Time after Reagent Add (hrs)			0	0	0.125	0.25	0.5	1	2	3	4	6	8	674
Identity	Units	Method												
Quantity collected	grams		3.98	5.27	44.26	40.46	43.51	50.78	47.06	45.51	41.71	67.36	84.78	
ADS Sample No.			169764	170431	170432	170433	170434	170435	170436	170437	170438	170439	170440	172484
Pretreatment: 0.25 gm of solids disolved in aquaregia (9 ml HCl + 3 ml HNO_3) then diluted with water to 250 ml														
Cd	µg/gm	ICP-MS	<1	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<2
La	µg/gm	ICP-MS	528	150	383	512	486	529	557	535	597	618	492	12.9
Ce	µg/gm	ICP-MS	843	170	422	567	550	583	624	606	671	703	560	22.7
Nd	µg/gm	ICP-MS	1720	291	778	1040	993	1060	1140	1080	1220	1260	1010	32.2
Re	µg/gm	ICP-MS	2.1	14.5	12.7	18.2	19.8	20.6	17.7	18.3	15.2	15.6	20.8	9.35
Pb	µg/gm	ICP-MS	413	1080	2520	3410	3230	3410	3660	3490	3910	4090	3230	479
Al	µg/gm	ICP-ES	30100	5030	547	549	473	638	851	720	1010	1410	649	3220
B	µg/gm	ICP-ES	910	<250	<250	<250	<250	<250	<250	<250	<250	<250	<250	3450
Ba	µg/gm	ICP-ES	21	22	1270	1050	989	1070	1170	1110	1220	1240	989	2540
Ca	µg/gm	ICP-ES	87900	3720	4680	3800	3710	4180	4500	4140	4470	4960	3960	1650
Cd	µg/gm	ICP-ES	<15	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<4.0
Cr	µg/gm	ICP-ES	925	1780	525	488	522	457	528	462	553	701	446	163
Fe	µg/gm	ICP-ES	48600	58500	26700	22400	21300	22900	24500	23500	26000	27000	21400	3410
Mg	µg/gm	ICP-ES	2880	12400	1410	1150	1130	1190	1280	1240	1320	1390	1090	201
Mn	µg/gm	ICP-ES	26000	33900	75300	61500	58600	64100	70500	65200	71200	72500	58300	12100
Na	µg/gm	ICP-ES	165000	204000	141000	182000	183000	198000	187000	174000	149000	166000	204000	111000
Ni	µg/gm	ICP-ES	<70	243	247	306	318	417	376	304	227	322	408	189
P	µg/gm	ICP-ES	1140	<750	<750	<750	<750	<750	<750	<750	<750	<750	<750	184
Pb	µg/gm	ICP-ES	<700	983	3730	3240	3170	3290	3710	3330	3740	3960	3180	492
Si	µg/gm	ICP-ES	2250	1120	274	427	145	485	490	233	259	423	378	225
Sr	µg/gm	ICP-ES	743	66	177000	146000	141000	152000	167000	154000	169000	174000	140000	459
Zr	µg/gm	ICP-ES	378	265	709	610	544	627	657	652	703	729	591	16
K	µg/gm	ICP-ES	<500	1040	1400	1800	1880	2420	2010	1720	1620	1680	2200	3940
S	µg/gm	ICP-ES	1190	1150	1280	1880	1740	2000	1950	1760	1490	1900	2230	773
Nd	µg/gm	ICP-ES	1071	<300	1180	972	960	921	1040	959	1150	1210	1040	<100
Cu	µg/gm	ICP-ES	<50	58	110	85	76	94	96	106	96	99	103	18
Zn	µg/gm	ICP-ES												3740
ADS Sample No.			169774	170421	170422	170423	170424	170425	170426	170427	170428	170429	170430	
Pretreatment: 0.25 gram of solids fused with 1.5 gm Na_2O_2 + 1.0 gm NaOH, disolved in 25 ml of HCL, and diluted with water to 250 ml														
Al	µg/gm	ICP-ES	28300	46400	4600	4700	5100	5200	5100	5000	4800	5200	5000	
B	µg/gm	ICP-ES	247	<250	<250	<250	<250	<250	<250	<250	<250	<250	<250	
Ba	µg/gm	ICP-ES	50	89	1132	1104	1269	1126	1130	1258	1188	1224	1136	
Ca	µg/gm	ICP-ES	86100	4862	5034	5398	5718	6346	6774	5780	6488	5823	5573	
Cd	µg/gm	ICP-ES	36	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	
Cr	µg/gm	ICP-ES	2161	5515	820	854	880	895	824	859	919	991	845	
Fe	µg/gm	ICP-ES	26600	64600	24000	23300	26800	23100	23500	26500	25400	26200	24200	
Mg	µg/gm	ICP-ES	1430	14000	1190	1230	1350	1320	1250	1410	1340	1330	1130	
Mn	µg/gm	ICP-ES	16800	37600	67200	64900	75600	63600	64900	74300	70700	71700	65900	
Ni	µg/gm	ICP-ES	270	343	282	363	316	437	417	297	294	380	450	
P	µg/gm	ICP-ES	681	<700	<700	<700	<700	<700	<700	<700	<700	<700	<700	
Si	µg/gm	ICP-ES	7090	7860	1160	1130	1300	1030	1140	1100	1100	1030	1050	
Sr	µg/gm	ICP-ES	810	7210	145000	150000	164000	152000	144000	167000	158000	151000	138000	
Zn	µg/gm	ICP-ES		<400	<400	<400	<400	<400	<400	<400	<400	<400	<400	
K	µg/gm	ICP-ES	1460	595	1940	2010	1700	1900	2100	1610	1260	1910	2920	
S	µg/gm	ICP-ES	1950	909	1170	1500	1020	1420	1440	1020	1120	1580	1370	
Nd	µg/gm	ICP-ES	778	528	1410	1290	1440	1280	1310	1350	1370	1560	1160	
ADS Sample No.			169754	170374	170375	170376	170377	170378	170379	170380	170381	170382	170383	
Pretreatment: 0.25 gram of solids fused with 1.5 gm Na_2O_2 + 1.0 gm NaOH, then disolved by and diluted with water to 250 ml														
Fluoride	µg/ml	ICA	<198	869	130	306	207	246	384	282	172	280	225	
Formate ($HCOO^-$)	µg/ml	ICA	<989	4009	16743	14039	12542	17328	20668	11221	15455	15850	12241	
Nitrite (NO_2^-)	µg/ml	ICA	<989	16081	23743	35446	28874	37136	44908	33768	23819	35380	31862	
Phosphate (PO_4^{3-})	µg/ml	ICA	<989	<88	<94	150	<93	180	226	<93	<99	140	152	
Oxalate ($C_2O_4^{2-}$)	µg/ml	ICA	<989	226039	36806	42505	42992	45231	49436	47859	44101	48548	45106	
Chloride (Cl^-)	µg/ml	ICA	989	639	1068	1490	1174	1720	1940	1289	986	1551	1358	
Nitrate (NO_3^-)	µg/ml	ICA	2966	63840	92427	153814	116599	140153	175323	142136	109304	144817	126780	
Sulfate (SO_4^{2-})	µg/ml	ICA	2966	2598	3521	8505	5683	4373	5509	5251	4635	4759	5701	

BATCH #2 ANALYTICAL RESULTS														
								Solids Analysis						
EDL Sample No.			0S	1S	2S	3S	4S	5S	6S	7S	8S	9S	10S	Post-Filtration
Time after Reagent Add (hrs)			0	0	0.125	0.25	0.5	1	2	3	4	6	8	674
Identity	Units	Method												
ADS Sample No.			169784	170474	170475	170476	170477	170478	170479	170480	170481	170482	170483	172484
Solids microwave dried														
Total Carbon	μg/ml		39996	102600	35800	58600	38800	45400	37800	40800	21400	48800	48600	
TOC	μg/ml		16362	92000	22800	39000	24000	30800	23600	25000	15180	31800	31800	
TIC	μg/ml		23634	10400	12960	19500	14800	14400	16000	15960	6340	16840	16600	
Fluoride	μg/ml		147	842	157	239	222	277	470	255	179	285	198	
Formate ($HCOO^-$)	μg/ml		170	4410	15859	19150	14471	18436	16662	11298	16634	14766	13064	
Nitrite (NO_2^-)	μg/ml		169	15823	21879	37332	32929	36607	38391	34951	26248	27271	30652	
Phosphate (PO_4^{3-})	μg/ml		81	<92	<95	136	<95	188	262	84	<95	104	142	
Oxalate ($C_2O_4^{2-}$)	μg/ml		31269	198880	39924	43363	48354	43951	40128	57243	39756	27271	49182	
Chloride (Cl^-)	μg/ml		5533	878	902	1610	1173	1637	1538	1288	1037	1199	1267	
Nitrate (NO_3^-)	μg/ml		897	72872	94864	152580	120504	155045	192328	135608	110163	128537	121881	
Sulfate (SO_4^{2-})	μg/ml		278	2807	4558	4983	6493	5191	9302	7838	4349	5050	4845	
Al_2O_3(corundrum)		XRD	74-1081	46-1212										
MnO_2(pyrolusite)		XRD	24-0735	24-0735										
Fe_2O_3(Hermatite)		XRD	72-0469	86-2368										
$C_2CaO_4!H_2O$(Whewelite)		XRD	20-0231											
$CaCO_3$(calcite)		XRD	86-0174											
SiO_2(Quartz)		XRD	46-1045	46-1045										
$Mn(SO_3)H_2O$(Mang Sulf Hyd)		XRD	82-0764											
$C_2Na_2O_4$(Natroxalate)		XRD	20-1149	20-1149	49-1816	49-1816	49-1816	49-1816	49-1816	49-1816	49-1816	49-1816	49-1816	
$NaNO_3$(Sodium Nitrate)		XRD		72-0025	72-0027	72-0027	72-0027	72-0027	72-0027	72-0027	72-0027	72-0027	72-0027	
$SrCO_3$(Strontianite)		XRD			84-1778	84-1778	84-1778	84-1778	84-1778	84-1778	84-1778	84-1778	84-1778	
$Na_4Sr(SiO_3)_3$-Na,Sr, Silicate		XRD			06-0392	06-0392	06-0392	06-0392	06-0392	06-0392	06-0392	06-0392	06-0392	
$NiMn_2O_3(OH)_4!H_2O$(Asbolane)		XRD												42-1319

Note: Batch #2 0S is before caustic addition which is the same sample analysis as Batch #1 1S, and Batch #2 1S is sample analysis following caustic addition.

SRT-ADS-02-0031 SVOC Analysis of Solid Samples

ADS Number	Customer ID
300170474	RPP-WTP-PREC2-1S
300170475	RPP-WTP-PREC2-2S
300170476	RPP-WTP-PREC2-3S
300170477	RPP-WTP-PREC2-4S
300170478	RPP-WTP-PREC2-5S
300170479	RPP-WTP-PREC2-6S
300170480	RPP-WTP-PREC2-7S
300170481	RPP-WTP-PREC2-8S
300170482	RPP-WTP-PREC2-9S
300170483	RPP-WTP-PREC2-10S

Results

Ten samples were submitted for semivolatile organic compound (SVOC) analysis. The only SVOC analytes that were detected were phthalates, as well as adipate and maleate, commonly used as commercial plasticizers, as shown in the table below.
The method detection limit (MDL) for the samples in this study was 1 mg/kg.

Sample ID	DEP	DBP	DOA	DOM
RPP-WTP-PREC2-1S	252	17	15	7.3
RPP-WTP-PREC2-2S	8.3	_	_	_
RPP-WTP-PREC2-3S	9	_	_	_
RPP-WTP-PREC2-4S	9.6	_	_	_
RPP-WTP-PREC2-5S	8	_	_	_
RPP-WTP-PREC2-6S	6.5	_	_	_
RPP-WTP-PREC2-7S	6.7	_	_	_
RPP-WTP-PREC2-8S	6	_	_	_
RPP-WTP-PREC2-9S	5.8	_	_	_
RPP-WTP-PREC2-10S	5.1	_	_	_

DEP = Diethylphthalate
DBP = Dibutylphthalate
DOA = Diisooctyadipate
DOM = Diisooctylmaleate

Experimental

The liquid samples were extracted with methylene chloride and analyzed.

Gas Chromatography / Mass Spectrometry (GC/MS) analysis was employed to identify organic compounds in the sample. Analysis were carried out in building 773-A, laboratory B-123. It should be noted that ADS is not certified by DHEC for NPDES discharge compliance monitoring. Analytical separations were carried out on a Hewlett Packard 6890 gas chromatograph, equipped with a 30 m DB-5 column, with 0.25 mm diameter and 0.25 um film thickness. Quantitation was performed using a Hewlett Packard 5973 mass selective detector. The mass spectrometer tuning was confirmed within 24 hours prior to each measurement using perfluorotributylamine.

GC/MS Analysis Results-VOC
solid, liquid, gas samples no detectable VOC analytes

SRT-ADS-01-0537

Sample ID

ADS Number	EDL Sample No.
3-170441	RPP-WPT-PRECIP2-1G
3-170442	RPP-WPT-PRECIP2-2G
3-170443	RPP-WPT-PRECIP2-3G
3-170444	RPP-WPT-PRECIP2-4G
3-170445	(RPP-WTP-PREC2-1L)
3-170446	(RPP-WTP-PREC2-2L)
3-170447	(RPP-WTP-PREC2-3L)
3-170448	(RPP-WTP-PREC2-4L)
3-170449	(RPP-WTP-PREC2-5L)
3-170450	(RPP-WTP-PREC2-6L)
3-170451	(RPP-WTP-PREC2-7L)
3-170452	(RPP-WTP-PREC2-8L)
3-170453	(RPP-WTP-PREC2-9L)
3-170454	(RPP-WTP-PREC2-10L)
3-170474	(RPP-WTP-PREC2-1S)
3-170475	(RPP-WTP-PREC2-2S)
3-170476	(RPP-WTP-PREC2-3S)
3-170477	(RPP-WTP-PREC2-4S)
3-170478	(RPP-WTP-PREC2-5S)
3-170479	(RPP-WTP-PREC2-6S)
3-170480	(RPP-WTP-PREC2-7S)
3-170481	(RPP-WTP-PREC2-8S)
3-170482	(RPP-WTP-PREC2-9S)
3-170483	(RPP-WTP-PREC2-10S)

Results

Ten solid, ten liquid, and four gas samples were submitted for volatile organic compounds (VOC) analysis.
The samples did not contain any detectable VOC analytes, and the limits of detection for this study are tabulated below.

Sample Matrix	MDL	
Gas	0.2	ppmv
Liquid (Aqueous)	1	ug/L
Solid	10	ug/kg

Experimental

Solid, liquid, and gas samples were analyzed using purge and trap Gas Chromatography / Mass Spectrometry (GC/MS).
GC/MS analysis was employed to identify organic compounds in the samples. Analyses were carried out in building 773-A, laboratory B-159. It should be noted that ADS is not certified by DHEC for NPDES discharge compliance monitoring.
Samples were concentrated using a Tekmar 2016 Purge and Trap concentrator, using a three stage (10 cm Carbopack B / 6 cm Carboxen 1000 / 1 cm Carboxen 1001) trap. Analytical separations were carried out on a Hewlett Packard 6890 gas chromatograph, equipped with a 20 m DB-624 column, with 0.18 mm diameter and 1.0 um film thickness.
Quantification was performed using a Hewlett Packard 5973 mass selective detector.
The mass spectrometer tuning was confirmed within 24 hours prior to each measurement using perfluorotributylamine.
Some VOC samples for this study were analyzed on the following instrument.
Volatile organic analyses were performed by Gas Chromatography - Mass Spectrometry (GC-MS), using the ADS method 2656 (Contract Laboratory Program SOW 7-93 for Volatile Organics).
Samples were concentrated using an OI Analytical model 4460A Dynamic Headspace concentrator (Purge and Trap), using a three stage (10 cm Carbopack B / 6 cm Carboxen 1000 / 1 cm Carboxen 1001) trap.
Separation was performed with a Hewlett Packard 5890 series II gas chromatograph on a 105m x 0.32 mm VOCOL glass capillary column with 3 um film thickness. Quantitation was performed with a Hewlett Packard model 5971 quadrupole mass spectrometer. Internal standard and recovery surrogate compounds were added as specified in the Contract Laboratory Program for volatile organics (SOW 7-93).
The mass spectrometer tuning was confirmed within 12 hours prior to each measurement using 4-bromofluorobenzene.
Tuning verification was performed against CLP tuning requirements, specifically to optimize CLP requirements for high mass sensitivity. 50/95 ratios which are between 8%-15%, may require appropriate flagging if used for other purposes.

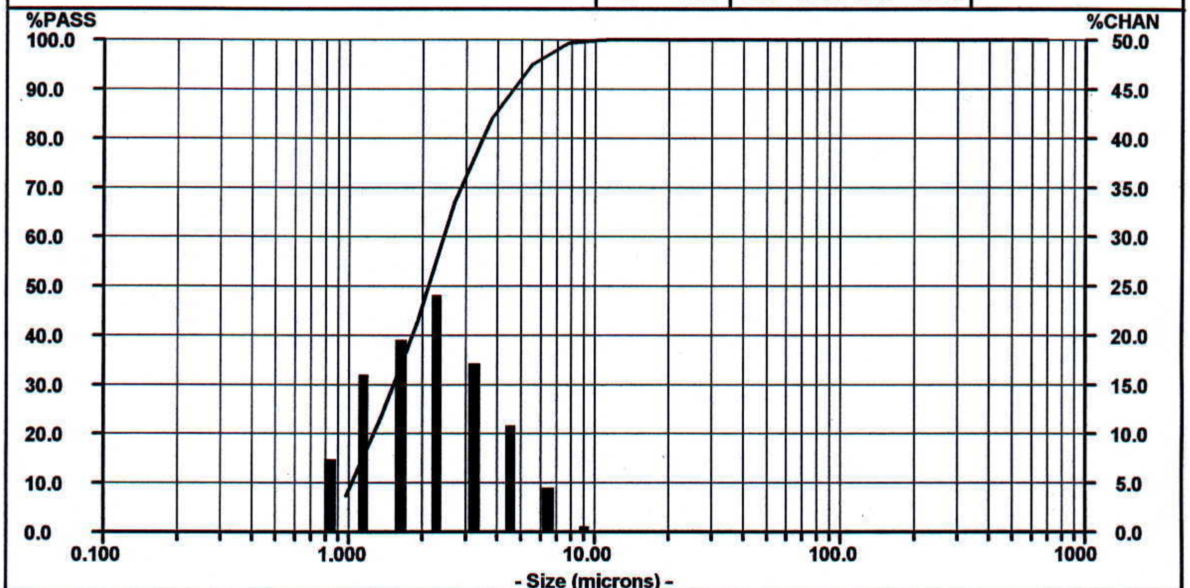
MICROTRAC - SRA150

Ver:7.01

Particle Size	3-172182 10% FSS w/solids	Date: 11/16/01 Meas #: 5135 Time: 07:36 Pres #: 1

Willams, Michael

Summary	Percentiles		Dia	Vol%	Width
mv = 2.513	10% = 1.040	60% = 2.477	2.153	100%	2.689
mn = 1.205	20% = 1.288	70% = 2.893			
ma = 1.870	30% = 1.558	80% = 3.528			
cs = 3.208	40% = 1.855	90% = 4.575			
sd = 1.345	50% = 2.153	95% = 5.503			



SIZE	%PASS	%CHAN
704.0	100.00	0.00
497.8	100.00	0.00
352.0	100.00	0.00
248.9	100.00	0.00
176.0	100.00	0.00
124.5	100.00	0.00
88.00	100.00	0.00
62.23	100.00	0.00
44.00	100.00	0.00
31.11	100.00	0.00
22.00	100.00	0.00
15.56	100.00	0.00
11.00	100.00	0.51
7.778	99.49	4.50
5.500	94.99	10.87
3.889	84.12	17.09
2.750	67.03	24.07
1.945	42.96	19.52
1.375	23.44	16.01
0.972	7.43	7.43

Distribution: Volume
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 20
High Resolution: No
Filter On: N/A

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: N/A
Particle Transparency: N/A
Particle Refractive Index: N/A
Particle Shape: N/A

Database Path: C:\MTWIN\PDPSD.DB

Fluid: N/A
Fluid Refractive Index: N/A
Loading Factor: 0.0285
Transmission: 0.90
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Lasentec Chord Length Data for Pilot-Scale Precipitation Run #2 Post Filtration Samples

Hanford AN-107 simulant samples were received from Engineering Development Laboratory personnel for analysis of post filtration solids. The samples were isolated at various times after the completion of precipitate reagent additions (on 10-23-01 at 9:47 hours) as indicated in Table 1 below. Each sample was immediately filtered through a 0.45 micron disposable Nalgene Nylon filter unit to yield approximately 1 L of filtrate. The samples were stored in 1L wide-mouth, amber polypropylene bottles to minimize interactions with light during storage. This bottle type allowed for Lasentec chord length analysis without removing the sample from the storage container. Samples were initially analyzed with the Lasentec within 24 hours of the filtration to determine whether any solids were present.

The Lasentec FBRM is a laser-based technique, which utilizes backscattered signal from particles within the detector measurement zone to obtain chord length data for a population of particles. The FBRM is a highly sensitive technique due to the fact that it measures backscattered laser intensity from individual particles within the sample. In addition, the method requires no sample preparation and is suitable for in-process analysis. These are significant advantages over traditional methods for the analysis of suspended solids in liquid media. The FBRM method requires that the particles be passed across the probe surface. This is generally achieved by placing the probe within a flowing liquid stream or (in the case of individual samples) by stirring the liquid using an appropriately designed and positioned impeller blade. A particle chord length is defined as the diameter of the particle as it is presented to the detector. For a given non-spherical particle, the particle may be presented to the detector in a number of orientations and a number of unique chords may be measured. Since the AN-107 simulant composition is complex, post-filtration solids may contain a mixture of particles with different compositions and morphologies (shapes). This adds to the complexity of the measured chord length distribution. In addition, as particle counts increase, the FBRM response may not be linear and the data cannot be considered to be highly quantitative unless suitable standards can be prepared and a calibration curve generated. Nonetheless, general comparisons of particle counts can sometimes be made between samples of the same type.

Table 1. AN-107 Filtrate Sample Isolation Times

Sample ID	Sample Collection Date/Time	Reaction Time Before Filtration (hr)
PF2-1	10-23-01/13:00	3.2
PF2-2	10-24-01/00:15	14.5
PF2-3	10-24-01/07:30	21.7
PF2-4	10-24-01/16:00	30.2
PF2-5	10-25-01/00:05	38.3
PF2-6	10-25-01/07:30	45.7

Figure 1 shows the chord length data obtained for selected samples from pilot scale precipitation test #2 after filtration. Table 2 provides the total chord length counts measured per second, the mean chord length for each sample, and the time that after filtration that each sample was analyzed. Sample PF2-2 was analyzed on two successive days (PF2-2-A and –B). Measurable solids were observed for samples PF2-5 and –6, although the total counts did not exceed 65 for either sample. The counts observed for samples PF2-2-A, -3, and –4 were below normal instrumental background levels (typically around 15 counts per second). Note that the counts per second provided in Table 2 cannot be directly related to weight % solids in the samples, since this measurement was not conducted. Visible solids could not be observed in any of these samples and it is unlikely that the total mass of solid material was high enough to be isolated and measured accurately. Significantly higher counts were observed for sample PF2-2-B approximately 23 hours after the initial analysis of this sample (PF2-2-A) although the total solid content was still very low and no solids were visually observed. The analysis of the –2-B sample does provide an idea of the formation time scale and size of the initial precipitate.

Table 2. Chord Length Data Obtained Following Filtration

Sample	Total Counts/sec	Mean Chord Length (μm)	Measurement Time After Filtration (hr)
PF2-1	Not measured	Not measured	Not measured
PF2-2-A	9	139	18.8
PF2-2-B	187	21	41.6
PF2-3	8	145	11.6
PF2-4	9	141	2.9
PF2-5	59	29	17.7
PF2-6	62	28	10.1

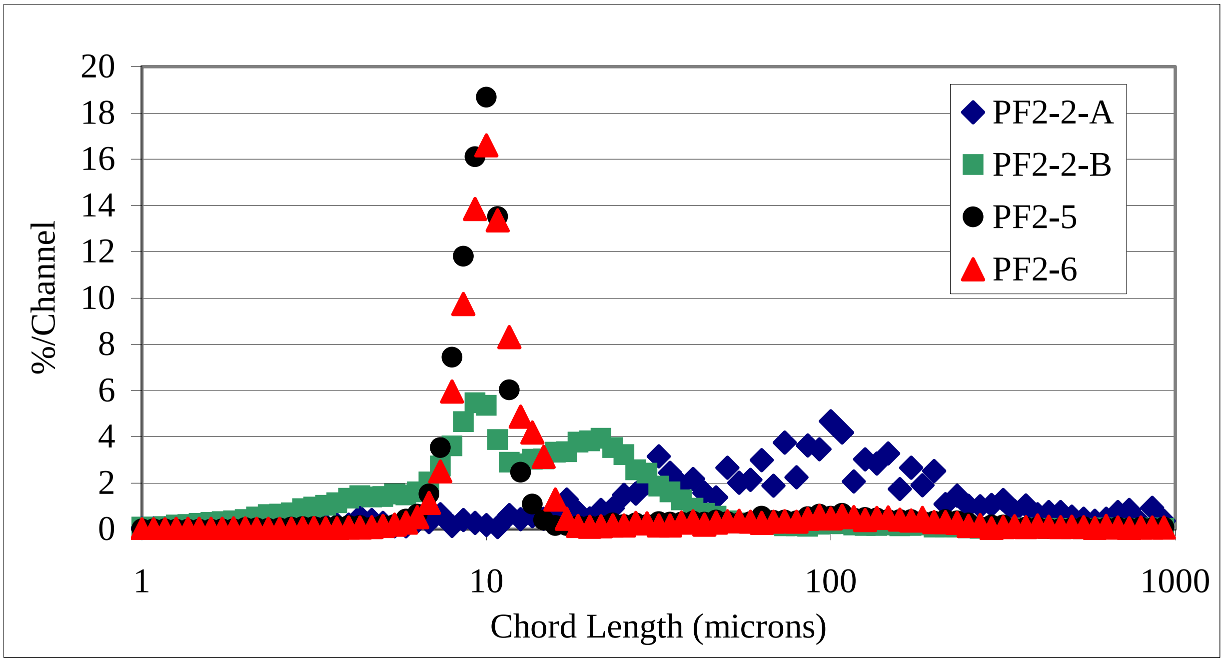


Figure 1. Pilot Scale Run #2 Chord Length Data After Filtration (Chord Length vs. %/Channel)

The samples were stored after analysis for nearly 5 months at ambient temperature in the amber bottles. The air headspace above the samples was <10% of the total volume. Table 3 provides the chord length data obtained for the samples after storage. The samples were all analyzed on 3-6-02. Visible solids were observed for all samples on the container bottoms and sides. Approximately 75% of the solids were removed from the container walls by shaking the bottles. The total counts and mean chord lengths for all measured samples were similar (average counts: 2040; average mean chord length: 27 µm). The chord length distribution shown in Figure 2 for sample PF2-2 is typical of the distributions observed for the other samples.

Table 3. Chord Length Data Obtained After Storage for Several Months

Sample	Total Counts/sec	Mean Chord Length (µm)
PF2-1	2013	33
PF2-2	1972	28
PF2-3	2030	23
PF2-4	2256	24
PF2-5	1931	27
PF2-6	Not measured	Not measured

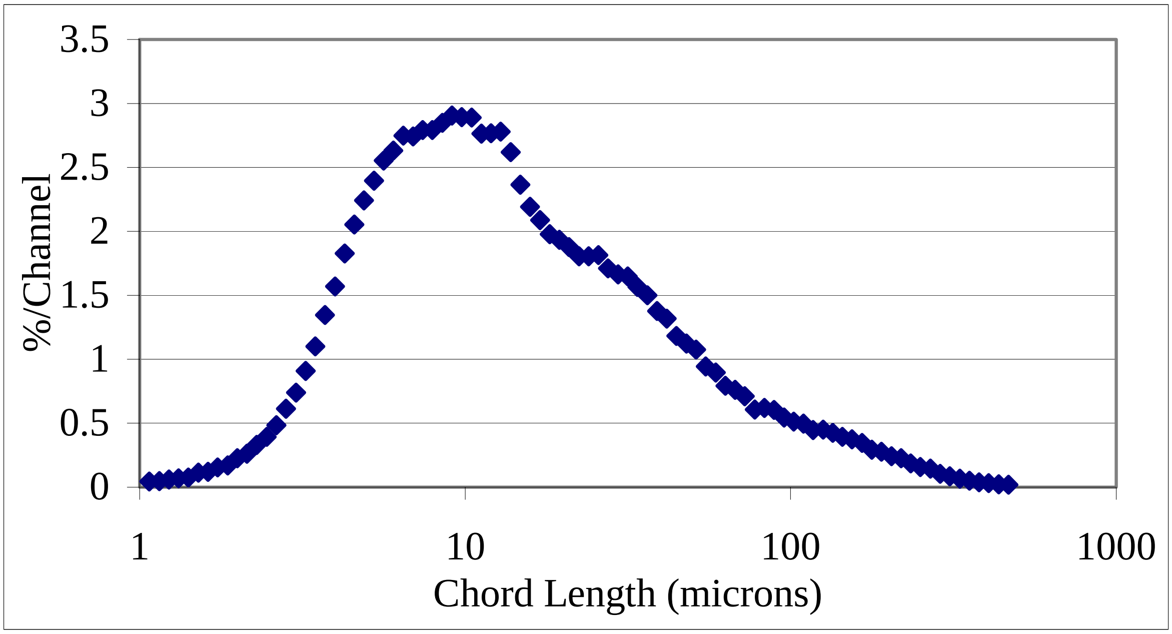


Figure 2. Pilot Scale Run #2 Chord Length Data for Sample PF2-2 After Storage (Chord Length vs. %/channel)

APPENDIX E

Batch 3C Analytical Data

Appendix Contents

- Liquid, Solid, and Gas Sample Analyses
- Lasentec Data

Special Notes:

- Each Solid Sample was divided into four segments for various dissolutions and analyses except the post-filtration solids which were not subdivided due to their small quantity.
- < values indicate below detection limits.
- Slurry supernate from Batch 1 stored for one year was used to condition the Cross-flow filter prior to processing Batch 3C precipitated slurry.
- Batch 3A material was processed through the CUF as a mini-precipitation (29) prior to Batch 3C processing on the pilot scale.
- The identification of materials by the X-ray Diffraction (XRD) method was performed in accordance with the International Center for Diffraction Data at www.icdd.com using the Powder Diffraction Database of PDF cards.

BATCH 3C ANALYSIS

Sample Description			AN-102R2 Slurry Expected based on Mixed Amounts	AN-102R2 Supernate Expected based on Mixed Amounts	AN-102R2 simulant at 6.5M Na before aging			AN-102R2 simulant at 6.5M Na after aging one week			AN-102R2 simulant at 6.0M Na with solids		
						tjs	tjs		tjs	tjs		tjs	tjs
EDL Sample No.					3C-1SL	3C-1SL		3C-2SL	3C-2SL		3C-3SL	3C-3SL	
Time after Reagent Addition (hrs)						N/A			N/A			N/A	
Density		g/ml				1.28	1.28		1.34	1.34		1.32	1.32
pH		pH				9.75	9.75		11.0	11.0		11.0	11.0
Total Solids		wt%				35.8			36.2			33.8	
Soluble Solids		wt%				35.4			35.6			33.3	
Insoluble Solids		wt%				0.310			0.623			0.526	
ADS or ML Sample No.			N/A		185683	02-9806	02-9806	185684	02-9812	02-9812	185685	02-9857	02-9857
Material submitted for ICP analysis					Slurry	Slurry		Slurry	Slurry		Slurry	Slurry	
Filtered by ADS or ML before ICP					No	No	Yes	No	No	Yes	No	No	Yes
Analysis	Method	Units											
Al	ICP-ES	µg/gm	9576	9545	7550	8120	8360	7600	7840	7490	7030	7510	7040
B	ICP-ES	µg/gm	21.7	21.7	25.0	30.6	35.5	31	40.1	34.8	37	38.9	36.9
Ba	ICP-ES	µg/gm	0.125	0.000	<0.5	<0.010	<0.010	<0.5	<0.500	<0.010	<0.5	<0.500	<0.010
Ca	ICP-ES	µg/gm	289	289	283	469	358	302	498	189	247	274	187
Cd	ICP-ES	µg/gm	35.8	35.8	38	35.9	37.9	38	12.0	34.4	36	9.33	37.1
Ce	ICP-ES	µg/gm	26.2	26.3	24	23.0	24.0	24	17.1	23.3	36	14.9	24.2
Co	ICP-ES	µg/gm	1.61	1.62	<3.0	0.610	1.16	<3.0	<0.500	1.04	<3.0	<0.500	1.18
Cr	ICP-ES	µg/gm	155	148	142	142	156	143	136	127	135	207	121
Cu	ICP-ES	µg/gm	13.8	13.8	15	16.0	4.95	15	14.4	4.01	14	13.1	11.3
Fe	ICP-ES	µg/gm	29.0	24.6	39	36.8	24.1	54	35.0	22.3	41	359	24.7
K	ICP-ES	µg/gm	1171	1173	1290	2710	2560	1320	2840	1930	1210	2560	1970
La	ICP-ES	µg/gm	22.7	22.7	23	22.4	20.1	<40	9.10	18.3	<40	5.00	18.4
Mg	ICP-ES	µg/gm	0	0	17	13.6	<0.010	16	<0.500	<0.010	15	<0.500	3.83
Mn	ICP-ES	µg/gm	18.2	17.2	18	15.5	13.4	19	<0.500	12.8	18	<0.500	13.5
Mo	ICP-ES	µg/gm	26.6	26.6	30	27.7	29.4	30	20.2	27.8	28	19.9	29.8
Na	ICP-ES	µg/gm	108883	108723	113000	117000	115000	114000	96100	99200	108000	100000	89500
Nd	ICP-ES	µg/gm	55.7	55.6	45	38.1	39.1	52	31.9	40.1	66	26.0	40.7
Ni	ICP-ES	µg/gm	246	246	260	222	241	260	224	159	245	243	161
P	ICP-ES	µg/gm	848	838	1090	1120	713	1120	1190	547	903	1210	632
Pb	ICP-ES	µg/gm	110	109	116	97.6	57.3	117	114	48.2	107	96.7	65.8
S	ICP-ES	µg/gm	2492	2486	2750	3250	8750	2740	3090	4920	2580	2960	13600
Si	ICP-ES	µg/gm	6.1	5.9	29	30.7	34.7	25	22.0	31.2	26	31.2	30.8
Sr	ICP-ES	µg/gm	2.44	2.44	2.7	8.61	4.05	2.9	<0.500	0.067	2.1	<0.500	0.135
W	ICP-ES	µg/gm	99.4	98.8		108	216		107	102		108	110
Zn	ICP-ES	µg/gm	3.03	2.96	<10	<0.010	3.06	<10	<0.500	2.75	<10	<0.500	3.40
Zr	ICP-ES	µg/gm	8.20	7.90	5.7	8.61	7.22	1.4	16.2	6.84	5.2	15.50	6.84
K	AAK	µg/gm	1171		1228			1536			971		
Na	AANA	µg/gm	108883		101549			108000			93114		
Cd	ICP-MS	µg/gm	35.8		37.3			39.0			35.5		
Ce	ICP-MS	µg/gm	26.2		27.6			28.4			26		
La	ICP-MS	µg/gm	22.7		23.7			24.5			22.4		
Nd	ICP-MS	µg/gm	55.7		48.7			50.7			46.4		
Pb	ICP-MS	µg/gm	110		117			122			112		
Sample No.					185673	02-9806	02-9806	185674	02-9812	02-9812	185675	02-9857	02-9857
Analysis	Method	Units											
Free OH⁻	Titration	molar			0.228			0.231			0.036		
Total OH⁻	Titration	molar			1.61			1.61			1.51		
Other Base	Titration	molar											
Chloride (Cl^-)	IC-Anion	µg/gm			2910		2690	22		2620	23		2420
Fluoride	IC-Anion	µg/gm			1040		1280	<20		1240	<20		1110
Formate ($HCOO^-$)	IC-Anion	µg/gm			4940		5910	NA		5660	NA		5000
Nitrate (NO_3^-)	IC-Anion	µg/gm			100000		98400	914		91700	947		88600
Nitrite (NO_2^-)	IC-Anion	µg/gm			38100		39200	334		37100	344		36100
Oxalate ($C_2O_4^{2-}$)	IC-Anion	µg/gm			381		<400	NA		<380	NA		<380
Phosphate (PO_4^{3-})	IC-Anion	µg/gm			3080		1507	<100		1500	<100		1610
Sulfate (SO_4^{2-})	IC-Anion	µg/gm			6430		8050	59		7760	61		7110
Total Carbon	TIC/TOC	µg/ml			10800			23400			3980		
TOC	TIC/TOC	µg/ml			6370			13700			2310		
TIC	TIC/TOC	µg/ml			4430			9680			1670		

Sample Description			AN-102R2 filtrate 7.5 min. after reagents added		AN-102R2 filtrate 30 min. after reagents added		AN-102R2 filtrate 2 hours after reagents added		AN-102R2 filtrate 4 hours after reagents added	AN-102R2 slurry 4 hours after reagents added		Batch 3A AN-102R2 Simulant run in CUF at newly optimized conditions, 4 hours after reagents added		AN-102R2 filtrate composite tank after filtration complete	
			tjs	tjs	tjs	tjs	tjs	tjs	TJS	tjs	tjs	tjs	tjs	tjs	tjs
EDL Sample No.			3C-3L	3C-3L	3C-5L	3C-5L	3C-7L		3C-9L	3C-4SL					
Time after Reagent Addition (hrs)			0.125		0.5		2		4	4		N/A			
Density		g/ml	1.30	1.30	1.30	1.30	1.30	1.30	1.26	1.34	1.34	1.30	1.30	1.30	1.30
pH		pH	10.8	10.8	10.7	10.7	10.7	10.7	10.7	11.0	11.0	11.4	11.4	10.8	10.8
Total Solids		wt%	32.7		32.6		32.6		32.0	33.5		32.9		32.6	
Soluble Solids		wt%	<0.500		<0.500		<0.500		32.0	32.0		32.3		<0.500	
Insoluble Solids		wt%	32.7		32.6		32.6		<0.100	1.60		0.583		32.6	
ADS or ML Sample No.			02-1227	02-1227	02-1228	02-1228	02-1229	02-1229	02-1893	02-9858	02-9858	02-9811	02-9811	02-1226	02-1226
Material submitted for ICP analysis			DE Filtrate		DE Filtrate		DE Filtrate		DE Filtrate	Slurry		Slurry		Filtrate	Filtrate
Filtered by ADS or ML before ICP			No	Yes	No	Yes	No	Yes	No	No	Yes	No	Yes	No	Yes
Analysis	Method	Units													
Al	ICP-ES	µg/gm	7349	7446	7138	7462	7349	7462	6830	6840	6550	7060	7200	7108	7454
B	ICP-ES	µg/gm	42.1	68.2	42.8	69.0	42.5	66.6	27.3	36.2	27.3	27.1	27.3	49.5	68.0
Ba	ICP-ES	µg/gm	<0.385	<0.008	<0.385	<0.008	<0.385	<0.008	<0.100	<0.500	<0.010	13.7	<0.010	<0.385	<0.008
Ca	ICP-ES	µg/gm	88.5	85.4	92.3	88.5	88.5	96.9	106	253	66.7	394.0	81.5	111.5	106.2
Cd	ICP-ES	µg/gm	<1.154	26.5	<1.154	26.6	<1.154	28.1	21.7	7.30	26.2	31.5	28.5	<1.154	26.5
Ce	ICP-ES	µg/gm	<12.308	5.12	<12.308	4.92	<12.308	4.91	3.36	13.7	4.43	20.3	4.68	<12.308	3.74
Co	ICP-ES	µg/gm	<0.385	<0.008	<0.385	<0.008	<0.385	<0.008	<1.00	<0.500	<0.010	<0.010	<0.010	<0.385	<0.008
Cr	ICP-ES	µg/gm	111	118	108	105	109	116	123	123	115	114	112	112	114
Cu	ICP-ES	µg/gm	<3.85	1.8	<3.85	1.8	<3.85	1.9	2.07	11.60	1.52	14.1	2.86	<3.85	1.8
Fe	ICP-ES	µg/gm	<1.5	1.5	11.7	1.4	<1.538	1.9	<0.200	41.4	0.946	37.8	0.681	42.6	0.6
K	ICP-ES	µg/gm	2592	2069	2505	2208	2494	2138	2150	2420	1680	2310	2000	2575	1977
La	ICP-ES	µg/gm	<3.846	3.73	<3.846	3.57	<3.846	3.42	<0.400	5.40	2.67	19.50	2.95	<3.846	2.25
Mg	ICP-ES	µg/gm	<1.538	<0.031	<1.538	<0.031	<1.538	<0.031	<0.100	<0.500	<0.010	12.4	<0.010	<1.538	<0.031
Mn	ICP-ES	µg/gm	<0.385	3.34	<0.385	2.80	<0.385	3.74	<0.100	1310	3.86	1410.00	6.92	<0.385	5.42
Mo	ICP-ES	µg/gm	26.5	23.4	25.8	23.5	26.1	24.5	25.5	17.2	22.4	24.5	23.2	26.2	23.5
Na	ICP-ES	µg/gm	105385	85385	104615	83846	103077	85385	101000	92700	84300	103000	93800	104615	100769
Nd	ICP-ES	µg/gm	<7.692	10.2	<7.692	9.6	<7.692	9.1	6.46	24.20	6.92	22.3	4.46	<7.692	6.2
Ni	ICP-ES	µg/gm	215	154	215	155	214	162	187	199	139	199	186	218	153
P	ICP-ES	µg/gm	649	610	635	546	627	600	629	1120	577	875	846	583	529
Pb	ICP-ES	µg/gm	<7.692	11.5	<7.692	11.7	<7.692	13.5	12.5	91.4	14.8	86.7	19.8	<7.692	15.6
S	ICP-ES	µg/gm	2618	2395	2585	2546	2596	2485	2600	2730	6240	2880	3350	2640	2292
Si	ICP-ES	µg/gm	43.6	25.2	50.6	25.6	43.2	29.0	27.9	13.8	25.9	27.1	26.8	108.5	26.5
Sr	ICP-ES	µg/gm	86.2	36.5	83.1	38.5	58.3	39.3	44.9	2040	16.4	2740	78.5	29.8	19.2
W	ICP-ES	µg/gm	87.7	82.3	85.4	81.5	88.5	86.9	90.8	103.0	81.1	96.3	98.4	90.0	85.4
Zn	ICP-ES	µg/gm	<0.385	<0.008	<0.385	<0.008	<0.385	<0.008	<0.100	<0.500	0.550	<0.010	0.823	<0.385	<0.008
Zr	ICP-ES	µg/gm	<0.77	1.79	<0.77	1.75	<0.769	1.85	<0.100	14.8	2.19	7.38	2.38	<0.769	1.57
K	AAK	µg/gm													
Na	AANA	µg/gm													
Cd	ICP-MS	µg/gm													
Ce	ICP-MS	µg/gm													
La	ICP-MS	µg/gm													
Nd	ICP-MS	µg/gm													
Pb	ICP-MS	µg/gm													
Sample No.			02-1227	02-1227	02-1228	02-1228	02-1229	02-1229	02-1893	02-9858	02-9858	02-9811	02-9811	02-1226	02-1226
Analysis	Method	Units													
Free OH⁻	Titration	molar													
Total OH⁻	Titration	molar													
Other Base	Titration	molar													
Chloride (Cl^-)	IC-Anion	µg/gm		2269		2338		2308	2460		2170		2150		2285
Fluoride	IC-Anion	µg/gm		1023		1054		1054	573		955		1000		1008
Formate ($HCOO^-$)	IC-Anion	µg/gm		4508		4631		4654	4857		4380		4890		4615
Nitrate (NO_3^-)	IC-Anion	µg/gm		89231		91538		90000	91270		83600		85400		90000
Nitrite (NO_2^-)	IC-Anion	µg/gm		34846		35462		34615	35635		32500		33200		34615
Oxalate ($C_2O_4^{2-}$)	IC-Anion	µg/gm		838		838		<385	575		<380		861		823
Phosphate (PO_4^{3-})	IC-Anion	µg/gm		1531		1554		1485	1516		1280		1950		1377
Sulfate (SO_4^{2-})	IC-Anion	µg/gm		6692		6846		6769	7063		6400		6750		6692
Total Carbon	TIC/TOC	µg/ml													
TOC	TIC/TOC	µg/ml													
TIC	TIC/TOC	µg/ml													

Sample Description			AN-102R2 filtrate composite tank 1 day after filtration complete		AN-102R2 filtrate composite tank 2 days after concentration complete		AN-102R2 slurry after concentration in crossflow filter		1 yr old AN-107 slurry used to condition Xflow for 3C		AN-107 slurry after one yr stored to Xflow
			tjs	tjs	tjs	tjs	tjs	tjs			
EDL Sample No.							3C-7SL ?				3C-4SL
Time after Reagent Addition (hrs)							50 ?		8700		0
Density		g/ml	1.30	1.30	1.30	1.30	1.35	1.35		1.28	
pH		pH	10.8	10.8	10.7	10.7	10.5	10.5		11.1	
Total Solids		wt%					40.0				
Soluble Solids		wt%					28.0				
Insoluble Solids		wt%					12.0				
ADS or ML Sample No.			02-1225	02-1225	02-1230	02-1230	02-1231	02-1231		02-9669	185686
Material submitted for ICP analysis			Filtrate	Filtrate	Filtrate	Filtrate					
Filtered by ADS or ML before ICP			No	Yes	No	Yes	No	Yes			
Analysis	Method	Units									
Al	ICP-ES	µg/gm	7460	7462	7097	6846	6820	5870		44	6680
B	ICP-ES	µg/gm	40.1	72.7	42.2	63.2	29.2	21.1		22.8	20
Ba	ICP-ES	µg/gm	<0.385	<0.008	<0.385	<0.008	134	<0.100		<0.008	20
Ca	ICP-ES	µg/gm	112.3	104.6	103.8	104.6	2480	164		19.6	281
Cd	ICP-ES	µg/gm	<1.154	27.0	<1.154	26.4	16.8	19.6		<0.031	33
Ce	ICP-ES	µg/gm	<12.308	3.74	<12.308	3.72	203	2.84		0.35	30
Co	ICP-ES	µg/gm	<0.385	<0.008	<0.385	<0.008	7.14	<1.00		<0.008	<2.0
Cr	ICP-ES	µg/gm	110	116	108	116	101	68.6		52	125
Cu	ICP-ES	µg/gm	<3.85	1.7	<3.85	1.8	110	2.05		16.8	14
Fe	ICP-ES	µg/gm	<1.538	0.9	<1.538	0.6	264	<0.200		171.9	56
K	ICP-ES	µg/gm	2562	2154	2508	1892	2030	2150		1945	1210
La	ICP-ES	µg/gm	<3.846	2.24	<3.846	2.25	176	<0.400		<0.031	30
Mg	ICP-ES	µg/gm	<1.538	<0.031	<1.538	<0.031	89.1	<0.100		4	15
Mn	ICP-ES	µg/gm	<0.385	5.19	<0.385	5.18	11500.00	<0.100		521.88	1380
Mo	ICP-ES	µg/gm	25.7	23.5	26.5	23.2	0.0	0.0		15.8	23.9
Na	ICP-ES	µg/gm	90769	92308	101538	100769	111000	100000		85938	106000
Nd	ICP-ES	µg/gm	<7.692	6.2	<7.692	6.3	306	1.26		0.6	36
Ni	ICP-ES	µg/gm	213	153	209	152	343	151		235	230
P	ICP-ES	µg/gm	562	540	563	538	4880	333		161	1080
Pb	ICP-ES	µg/gm	<7.692	15.2	<7.692	15.1	650	10.8		27.3	106
S	ICP-ES	µg/gm	2647	2485	2578	2231	2130	2140		1492	2470
Si	ICP-ES	µg/gm	44.1	26.7	37.3	26.2	61.7	26.8		2.9	24
Sr	ICP-ES	µg/gm	36.8	19.2	29.2	19.6	24800.0	24.1		3.6	2730
W	ICP-ES	µg/gm	89.2	84.6	91.5	83.8	100.0	96.2		<0.391	91
Zn	ICP-ES	µg/gm	<0.385	<0.008	<0.385	<0.008	<0.100	<0.100		21.0	<10
Zr	ICP-ES	µg/gm	<0.769	1.68	<0.769	1.55	34.3	<0.100		21.88	7
K	AAK	µg/gm									1124.2
Na	AANA	µg/gm									104000
Cd	ICP-MS	µg/gm									34.7
Ce	ICP-MS	µg/gm									25.5
La	ICP-MS	µg/gm									22
Nd	ICP-MS	µg/gm									45.2
Pb	ICP-MS	µg/gm									110
Sample No.			02-1225	02-1225	02-1230	02-1230	02-1231	02-1231	185989	02-9669	185676
Analysis	Method	Units									
Free OH⁻	Titration	molar							<.02		<.002
Total OH⁻	Titration	molar							0.684		1.49
Other Base	Titration	molar									
Chloride (Cl^-)	IC-Anion	µg/gm		2246		2277		2141		716	23
Fluoride	IC-Anion	µg/gm		1000		985		609		1969	<20
Formate ($HCOO^-$)	IC-Anion	µg/gm		4638		4631		4889		4438	NA
Nitrate (NO_3^-)	IC-Anion	µg/gm		88462		90000		84444		96094	1020
Nitrite (NO_2^-)	IC-Anion	µg/gm		34154		34462		32667		23438	356
Oxalate ($C_2O_4^{2-}$)	IC-Anion	µg/gm		<385		838		<370		977	NA
Phosphate (PO_4^{3-})	IC-Anion	µg/gm		1346		1346		1000		<391	<100
Sulfate (SO_4^{2-})	IC-Anion	µg/gm		6623		6677		6756		3680	62
Total Carbon	TIC/TOC	µg/ml									18200
TOC	TIC/TOC	µg/ml									10300
TIC	TIC/TOC	µg/ml									7870

BATCH 3C ANALYTICAL RESULTS								
			Solids Analysis					
EDL Sample No.			AN-102R2 simulant at 6.5M Na before aging	AN-102R2 simulant at 6.5M Na after aging 1 week	AN-102R2 simulant at 6.5M Na after dilution and solids	Batch 3A CUF AN-102R2 slurry 4 hours after reagents added	AN-102R2 slurry 4 hours after reagents added	AN-107 slurry after one yr stored to Xflow
Time after Reagent Add (hrs)			0	0	0	4	4	8000+
Identity	Units	Method						
Quantity collected	grams							
Mobile Lab Sample No.			02-9806	02-9812	02-9857	02-9811	02-9858	02-9669
Pretreatment: 0.25 gm of solids disolved in aquaregia ($HCl:HNO_3$) then diluted with water to 250 ml								
Al	µg/gm	ICP-ES	8120	7840	7510	7060	6840	267
B	µg/gm	ICP-ES	30.6	40.1	38.9	27.1	36.2	24.8
Ba	µg/gm	ICP-ES	<0.010	<0.500	<0.500	13.7	<0.500	36.9
Ca	µg/gm	ICP-ES	469	498	274	394	253	438
Cd	µg/gm	ICP-ES	35.9	12	9.33	31.5	7.3	<0.040
Ce	µg/gm	ICP-ES	23	17.1	14.9	20.3	13.7	19.7
Co	µg/gm	ICP-ES	0.61	<0.500	<0.500	<0.010	<0.500	<0.010
Cr	µg/gm	ICP-ES	142	136	207	114	123	78.8
Cu	µg/gm	ICP-ES	16	14.4	13.1	14.1	11.5	14.2
Fe	µg/gm	ICP-ES	36.8	35	359	37.8	41.4	716
K	µg/gm	ICP-ES	2710	2840	2560	2310	2420	2330
La	µg/gm	ICP-ES	22.4	9.1	5	19.5	5.4	17.7
Mg	µg/gm	ICP-ES	13.6	<0.500	<0.500	12.4	<0.500	45
Mn	µg/gm	ICP-ES	15.5	<0.500	<0.500	1410	1310	2260
Mo	µg/gm	ICP-ES	27.7	20.2	19.9	24.5	17.2	15.3
Na	µg/gm	ICP-ES	117000	96100	100000	103000	92700	89000
Nd	µg/gm	ICP-ES	38.1	31.9	26	22.3	24.2	31.3
Ni	µg/gm	ICP-ES	222	224	243	199	199	201
P	µg/gm	ICP-ES	1120	1190	1210	875	1120	231
Pb	µg/gm	ICP-ES	97.6	114	96.7	86.7	91.4	146
S	µg/gm	ICP-ES	3250	3090	2960	2880	2730	1600
Sr	µg/gm	ICP-ES	8.61	<0.500	<0.500	2740	2040	6530
Si	µg/gm	ICP-ES	30.7	22	31.2	27.1	13.8	25.4
W	µg/gm	ICP-ES	108	107	108	96.3	103	<0.500
Zn	µg/gm	ICP-ES	<0.010	<0.500	<0.500	<0.010	<0.500	20.3
Zr	µg/gm	ICP-ES	8.61	16.2	15.5	7.38	14.8	27.5

SRT-ADS-02-0529

Discussion of Results

One sample ADS 3-186616 (RPP-WTP-PREC3C-1VOA) was submitted for volatile organic compound (VOC) and permanent gas analysis. The detection limit for permanent gases was 0.1%, and for VOC analysis was 0.1 ppmv for this study. Results are tabulated below.

Analyte	Concentration
Oxygen	21%
Nitrogen	78%
Hydrogen	< 0.1 %
Decane	0.12 ppmv
Undecane	0.22 ppmv

Experimental - VOA

The sample was analyzed by purge and trap Gas Chromatography / Mass Spectrometry (GC/MS).
GC/MS analysis was employed to identify organic compounds in the samples. Analysis were carried out in building 773-A, laboratory B-159.
It should be noted that ADS is not certified by DHEC for NPDES discharge compliance monitoring.
Analytical separations were carried out on a Hewlett Packard 6890 gas chromatograph, equipped with a 20 m DB-624 column, with 0.18 mm diameter and 1.0 um film thickness. Quantitation was performed using a Hewlett Packard 5973 mass selective detector. The mass spectrometer tuning was confirmed within 24 hours prior to each measurement using perfluorotributylamine.

Experimental - permanent gas analysis

Permanent gas analysis were carried out on a Hewlett Packard model 5890 gas chromatograph (GC) equipped with a molecular sieve column and thermal conductivity detector (TCD). Calibration was carried out prior to and after the sample analyses using Scott Gas Mix 218, as well as calibration verification using blank air. Samples were run in duplicate for confirmation of results.

SRT-ADS-02-0529, Revision 1

Discussion of Results

Two samples were recently submitted, one sample, ADS 3-186616 (RPP-WTP-PREC3C-1VOA) for volatile organic compound (VOC) analysis and ADS 3-186614 (RPP-WTP-PREC3C-1GC) for permanent gas analysis. The detection limit for permanent gases was 0.1%, and for VOC analysis was 0.1 ppmv for this study. Results are tabulated below.

Analyte	Concentration
Gases	
Oxygen	21%
Nitrogen	78%
Hydrogen	< 0.1 %
VOA	
Decane	0.12 ppmv
Undecane	0.22 ppmv

Experimental - VOA

The sample was analyzed by purge and trap Gas Chromatography / Mass Spectrometry (GC/MS).
GC/MS analysis was employed to identify organic compounds in the samples. Analysis were carried out in building 773-A, laboratory B-159.
It should be noted that ADS is not certified by DHEC for NPDES discharge compliance monitoring.
Analytical separations were carried out on a Hewlett Packard 6890 gas chromatograph, equipped with a 20 m DB-624 column, with 0.18 mm diameter and 1.0 um film thickness. Quantitation was performed using a Hewlett Packard 5973 mass selective detector. The mass spectrometer tuning was confirmed within 24 hours prior to each measurement using perfluorotributylamine.

Experimental - permanent gas analysis

Permanent gas analysis were carried out on a Hewlett Packard model 5890 gas chromatograph (GC) equipped with a molecular sieve column and thermal conductivity detector (TCD). Calibration was carried out prior to and after the sample analyses using Scott Gas Mix 218, as well as calibration verification using blank air. Samples were run in duplicate for confirmation of results.

Experimental

Solid, liquid, and gas samples were analyzed using purge and trap Gas Chromatography / Mass Spectrometry (GC/MS).
GC/MS analysis was employed to identify organic compounds in the samples. Analyses were carried out in building 773-A, laboratory B-159. It should be noted that ADS is not certified by DHEC for NPDES discharge compliance monitoring.
Samples were concentrated using a Tekmar 2016 Purge and Trap concentrator, using a three stage (10 cm Carbopack B / 6 cm Carboxen 1000 / 1 cm Carboxen 1001) trap. Analytical separations were carried out on a Hewlett Packard 6890 gas chromatograph, equipped with a 20 m DB-624 column, with 0.18 mm diameter and 1.0 um film thickness.
Quantification was performed using a Hewlett Packard 5973 mass selective detector.
The mass spectrometer tuning was confirmed within 24 hours prior to each measurement using perfluorotributylamine.
Some VOC samples for this study were analyzed on the following instrument.
Volatile organic analyses were performed by Gas Chromatography - Mass Spectrometry (GC-MS), using the ADS method 2656 (Contract Laboratory Program SOW 7-93 for Volatile Organics).
Samples were concentrated using an OI Analytical model 4460A Dynamic Headspace concentrator (Purge and Trap), using a three stage (10 cm Carbopack B / 6 cm Carboxen 1000 / 1 cm Carboxen 1001) trap.
Separation was performed with a Hewlett Packard 5890 series II gas chromatograph on a 105m x 0.32 mm VOCOL glass capillary column with 3 um film thickness. Quantitation was performed with a Hewlett Packard model 5971 quadrupole mass spectrometer. Internal standard and recovery surrogate compounds were added as specified in the Contract Laboratory Program for volatile organics (SOW 7-93).
The mass spectrometer tuning was confirmed within 12 hours prior to each measurement using 4-bromofluorobenzene.
Tuning verification was performed against CLP tuning requirements, specifically to optimize CLP requirements for high mass sensitivity.
50/95 ratios which are between 8%-15%, may require appropriate flagging if used for other purposes.

Lasentec Data

A single large black plastic tank was covered with a thick white plastic sheet to eliminate light penetration. The filtrate from the crossflow filter was accumulated in the tank to represent the conditions that would exist in the filtrate receipt tanks in the plant. An agitator was provided to mix the tank, and a small pump was provided to obtain a sample from this composite tank whenever desired. A draw off from the crossflow filter also allowed samples to be obtained immediately after filtration. Both types of samples were collected and analyzed with the Lasentec particle analyzer.

The Lasentec analyzer was relocated to the EDL and operated by EDL personnel for Batch #3. Unfamiliarity with the instrument caused some difficulty in interpreting the readings. The small air bubbles entrained when collecting the samples had to be allowed to dissipate before valid readings could be taken. Small particles that stuck to the probe tip gave large counts at a single particle size; these results were meaningless simply indicating the probe needed to be cleaned. The data extracted from the logbook below has been edited slightly based on subsequent experience with the instrument.

At 1700 hours on 10/1/02, initial Lasentec data was taken from a filtrate sample collected in a gray container four hours after the reagents were added. Several one minute counts measured 60.5 microns at 18.8 counts/sec, 66.3 microns at 66.3 counts/sec, 70.8 microns at 13.2 counts/sec, 87.1 microns at 8.7 counts/sec and 101.4 microns at 6.0 counts/sec. Since the background count for the instrument is about 8 counts/sec (with 0.2 filtered deionized water), the above readings indicate very few solids in the filtrate (as would be expected immediately after crossflow filtration).

At 0923 hours on 10/2/02, a Lasentec sample was taken from the Composite Filtrate Tank twenty-one hours after reagents were added. The Lasentec measured subsequent one minute counts of 51.9 microns at 17.2 counts/sec, 53.7 microns at 15.4 counts/sec and 54.7 microns at 14.6 counts/sec.

At 1115 hours on 10/2/02, the initial Lasentec samples were re-measured with counts indicated at background levels. Similarly, the Lasentec sample taken from the Composite Tank at twelve hours after reagent addition measured counts at background levels. (In other words, the stored samples did not appear to be developing solids as they sat.)

At 1148 hours on 10/3/02, a Lasentec sample taken from the Composite Filtrate Tank measured close to background. The mean chord length of the sample measured was 50 to 110 microns at 6 to 12 counts/sec. Lasentec samples taken at four, twelve, and twenty-one hours after reagents added were re-measured and determined to have counts at the background level.

At 1110 hours on 10/4/02, the Composite Filtrate Tank was vigorously agitated and a sample taken for Lasentec measurement. The sample was allowed to stand until bubbles dissipated. Lasentec measurements were at background levels.

At 1528 hours on 10/9/02, a Lasentec sample removed from the Composite Filtrate Tank at 1200 hours was measured after bubbles dissipated. The mean chord length was 28.8 microns at 27.4 counts/sec, 30.3 microns at 31.0 counts/sec, 23.0 microns at 32.8 counts/sec and 32.7 microns at 25.0 counts/sec.

At 0825 hours on 10/14/02, the final Composite Tank sample was measured by the Lasentec for Batch 3C filtrate collected. The measurement showed a sharp peak at 14-15 microns at 79 counts/sec, 14.04 microns at 78.98 counts/sec, 14.11 microns at 78.73 counts/sec, 14.09 microns at 78.69 counts/sec, 14.18 microns at 78.59 counts/sec and 14.95 microns at 78.58 counts/sec. (Repeated sharp peaks like these were later shown to be caused by contamination on the probe, not by actual particles in the sample. The lack of measurements at other micron sizes indicates there were actually no significant particles present in the sample.)

APPENDIX F

Batch 3B Analytical Data

<u>Appendix Contents</u>

- Liquid, Solid, and Gas Sample Analyses
- Lasentec Data
- Post-Filtration XRD

Special Notes:

- Each Solid Sample was divided into four segments for various dissolutions and analyses.
- < values indicate below detection limits.
- The identification of materials by the X-ray Diffraction (XRD) method was performed in accordance with the International Center for Diffraction Data at www.icdd.com using the Powder Diffraction Database of PDF cards.

BATCH 3B ANALYSIS

Sample Description			OPTIMA input into AN-102R2		AN-102R2 simulant at 6.5M Na before aging		AN-102R2 simulant at 6.5M Na after aging one week			Batch 3B Simulant: AN-102R2 simulant diluted to 6.0M Na with entrained solids added					
EDL Sample No			3B-2SL	3B-2SL	3B-1SL	3B-1SL	3B-3SL	3B-3SL		3B-4SL	3B-4SL			3B-4SL	
Time after Reagent Add (hrs)			N/A		N/A		N/A			N/A	N/A				
lensity		g/ml		1.32		1.32		1.32	1.32		1.32	1.32	1.32	1.30	1.30
H		pH		11.3		11.4		11.1	11.1		10.7			10.8	10.8
otal Solids		wt%		34.8		35.6		36.1			33.4			33.7	
oluble Solids		wt%		34.4		35.3		35.7			33.2			33.3	
nsoluble Solids		wt%		0.435		0.276		0.390			0.220			0.376	
ADS or ML Sample No.			185334	02-9559	185333	02-9558	185335	02-9668	02-9668	185336	02-1544	02-1544 rerun	02-1544	02-1190	02-1190
aterial submitted for ICP analysis			Slurry	Slurry	Slurry	Slurry	Slurry	Slurry		Slurry		Slurry		Slurry	
Filtered by ADS or ML before ICP			No	Yes	No	Yes	No	No	Yes	No	No	No	Yes	No	Yes
nalysis	Method	Units													
l	ICP-ES	µg/gm	7100	7210	7550	7480	7410	7842	7800	7070	6920	7270	6940	7400	7180
l	ICP-ES	µg/gm	26	25.2	31	28.4	24	31.5	31.1	23	24.5	42.1	30.0	38.3	33.0
la	ICP-ES	µg/gm	<1.0	0.277	<1.0	0.338	<1.0	<0.010	<0.010	<1.0	<0.100	<0.100	2.92	<0.500	<0.010
a	ICP-ES	µg/gm	194	227	284	317	223	379	247	268	389	287	285	258	184
d	ICP-ES	µg/gm	<0.40	<0.020	39	25.6	37	35.0	32.6	36.0	20.3	26.4	19.1	9.51	34.0
e	ICP-ES	µg/gm	<19	<0.075	28.0	21.9	31	20.3	19.8	23	26.0	25.5	58.4	15.4	22.1
o	ICP-ES	µg/gm	<1.2	<0.400	2.3	1.33	2.3	<0.010	0.902	2.0	<1.00	<1.00	<1.00	<0.500	0.859
r	ICP-ES	µg/gm	127	108	131	120	127	124	106	123	104	118	100	122	107
u	ICP-ES	µg/gm	13.1	2.96	16.1	5.39	14.2	14.4	12.2	14	15.30	13.40	13.80	12.3	3.74
e	ICP-ES	µg/gm	47.3	16.7	55.8	21.1	37.2	29.4	23.7	39	25.2	22.8	23.4	38.7	21.7
	ICP-ES	µg/gm	1200	2160	1320	2410	1320	2670	2410	1290	2330	2250	2350	2550	1660
a	ICP-ES	µg/gm	<18	5.08	22	16.6	<18	13.9	14.9	23	21.6	18.0	52.8	5.80	16.4
Mg	ICP-ES	µg/gm	35	0.354	15	1.12	<2.5	<0.010	<0.010	14	<0.100	<0.100	<0.100	<0.500	<0.010
Mn	ICP-ES	µg/gm	10	4.60	19	11.1	26	22.2	17.3	26	17.8	9.06	8.8	2.90	13.0
Mo	ICP-ES	µg/gm	30	22.3	30	22.6	29	27.4	25.6	29		27.4		19.5	27.2
la	ICP-ES	µg/gm	117000	110000	112000	10600	108000	109000	103000	108000	10200	105000	105000	103000	94600
ld	ICP-ES	µg/gm	<7.0	<0.800	46	35.7	37	30.9	31.0	48	38.1	41.6	60.4	28.8	37.3
i	ICP-ES	µg/gm	206	134	261	206	240	203	184	244	182	205	168	216	156
	ICP-ES	µg/gm	605	375	1095	487	490	687	484	950	576	677	450	1080	569
b	ICP-ES	µg/gm	89	26.4	119	44.2	106	91.8	65.2	109	79.4	90.6	75.2	99.5	42.8
	ICP-ES	µg/gm	2270	2150	2830	2690	2740	3180	3140	2660	2150	2630	2080	2550	12000
i	ICP-ES	µg/gm	19	17.9	31	28.6	21	25.6	30.4	22	31.9	32.6	26.3	11.0	28.5
r	ICP-ES	µg/gm	4.1	6.50	3.1	4.05	26	53.7	5.46	26	53.5	24.2	31.0	<0.500	3.12
V	ICP-ES	µg/gm		<0.800		108		104	96.2		94	105	100	108	100
n	ICP-ES	µg/gm	<10	3.94	<10	3.06	<10	<0.010	2.92	<8.0	<0.100	<0.100	<0.100	<0.500	2.55
r	ICP-ES	µg/gm	7.6	6.31	5.3	5.33	3.1	6.17	5.39	6.5	3.25	2.60	8.11	14.9	5.47
	AAK	µg/gm	1095.3		1268.4		1236.1			1080					
la	AANA	µg/gm	104467.2		101587.1		100506.7			10900					
d	ICP-MS	µg/gm	0.09		37.5		36.7			36.0					
e	ICP-MS	µg/gm	<0.02		27.6		25.1			26.1					
a	ICP-MS	µg/gm	6.74		23.8		15.9			22.9					
ld	ICP-MS	µg/gm	<0.02		48.6		40.4			46.5					
b	ICP-MS	µg/gm	89.9		117		112			113					
Sample No.			185344	02-9559	185343	02-9558	185345	02-9668	02-9668	185346	02-1544	02-1544 rerun	02-1544	02-1190	02-1190
nalysis	Method	Units													
ree OH⁻	Titration	molar	0.546		0.203		0.141			0.185					
otal OH⁻	Titration	molar	2.15		1.70		1.61			1.54					
ther Base	Titration	molar	1.60		1.49		1.47			1.36					
hloride (Cl^-)	IC-Anion	µg/gm	1900	1860	3360	2800	27		2402	22			2356		2474
luoride (F^-)	IC-Anion	µg/gm	1130	773	1260	697	<20		1235	<20			1197		1191
ormate ($HCOO^-$)	IC-Anion	µg/gm	3710	4340	5430	5560	NA		5462	NA			5083		5224
itrate (NO_3^-)	IC-Anion	µg/gm	102000	97000	117000	10400	1150		87879	942			87879		89882
itrite (NO_2^-)	IC-Anion	µg/gm	45800	41200	49100	41300	423		34924	341			34697		36107
xalate ($C_2O_4^{2-}$)	IC-Anion	µg/gm	314	<770	359	<770	NA		<379	NA			<379		<384
hosphate (PO_4^{3-})	IC-Anion	µg/gm	2320	939	2960	1490	<100		1212	<100			2636		1536
ulfate (SO_4^{2-})	IC-Anion	µg/gm	6060	6300	9670	7800	75		7121	60			7121		7290
otal Carbon	TIC/TOC	µg/ml	17700		21000		20600			20000					
OC	TIC/TOC	µg/ml	7860		12900		12400			12100					
IC	TIC/TOC	µg/ml	9840		8150		8130			7940					

Sample Description			Batch 3B simulant after 0.8M caustic addion			Batch 3B simulant after 0.075M $Sr(NO_3)_2$ addition			Batch 3B filtrate 7.5 min. after reagents added			Batch 3B filtrate 30 min. after reagents added			Batch 3B filtrate 2 hours after reagents added		
EDL Sample No			3B-5SL	3B-2S/L		3B-6SL	3B-3S/L		3B-4L	3B-4L		3B-6L	3B-6L		3B-8L	3B-8L	
Time after Reagent Add (hrs)			N/A	N/A		N/A	N/A			0.125			0.5			2	
lensity		g/ml		1.32	1.32		1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
H		pH		10.8	10.8		10.8	10.8	10.8	10.8	10.8	10.7	10.7	10.7	10.7	10.7	10.7
otal Solids		wt%		35.5			34.6										
oluble Solids		wt%		34.8			33.0										
nsoluble Solids		wt%		0.620			1.58										
ADS or ML Sample No.			185337	02-1545	02-1545	185338	02-1546	02-1546	02-1547	02-1227	02-1227	02-1548	02-1228	02-1228	02-1550	02-1229	02-1229
aterial submitted for ICP analysis			Slurry	Slurry		Slurry	Slurry		DE Filtrate	DE Filtrate		DE Filtrate	DE Filtrate		Filtrate	DE Filtrate	
Filtered by ADS or ML before ICP			No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
nalysis	Method	Units															
l	ICP-ES	µg/gm	6940	7400	7680	6530	6560	7190	6940	7349	7446	6840	7138	7462	6750	7138	7462
l	ICP-ES	µg/gm	20	60.9	35.2	19	202	30.1	29.4	42.1	68.2	27.7	42.8	69.0	27.7	42.8	66.6
la	ICP-ES	µg/gm	<1.0	<0.100	<0.100	34	<0.100	<0.100	<0.100	<0.38	<0.01	<0.100	<0.38	<0.01	<0.100	<0.38	<0.01
a	ICP-ES	µg/gm	272	351	282	264	1630	165	57.5	88	85	56.6	92	88	65.8	92	97
d	ICP-ES	µg/gm	35.0	35.8	24.5	26.0	104	20.6	17.7	<1.15	26.5	18.6	<1.15	26.6	19.0	<1.15	28.1
e	ICP-ES	µg/gm	30	18.6	22.4	32	227	18.9	0.352	<12.308	5.1	<0.100	<12.308	4.9	<0.100	<12.308	4.9
o	ICP-ES	µg/gm	<2.0	<1.00	<1.00	<2.0	<0.100	<1.00	<1.00	<0.38	<0.01	<1.00	<0.38	<0.01	<1.00	<0.38	<0.01
r	ICP-ES	µg/gm	120	101	111	112	591	101	103	111	118	103	108	105	103	108	116
u	ICP-ES	µg/gm	13	14.8	13.2	13	64.4	12.1	0.569	<3.85	1.81	0.625	<3.85	1.75	1.69	<3.85	1.86
e	ICP-ES	µg/gm	41	16.3	24.7	41	80.1	21.4	<0.200	<1.54	1.5	<0.200	11.7	1.4	<0.200	11.7	1.9
	ICP-ES	µg/gm	1270	2870	2470	1190	16600	2290	2220	2592	2069	2180	2505	2208	2140	2505	2138
a	ICP-ES	µg/gm	21	3.23	16.4	21	175.0	3.59	<0.400	<3.846	3.7	<0.400	<3.846	3.6	<0.400	<3.846	3.4
Mg	ICP-ES	µg/gm	14	<0.100	<0.100	13	<0.100	<0.100	<0.100	<1.538	<0.031	<0.100	<1.538	<0.031	<0.100	<1.538	<0.031
Mn	ICP-ES	µg/gm	26	<0.100	9.18	23	41.6	10.7	<0.100	<0.385	3.3	<0.100	<0.385	2.8	<0.100	<0.385	3.7
Mo	ICP-ES	µg/gm	25.2	23.5	25.8	22.5	113	23.0	23.6	26.5	23.4	24.1	25.8	23.5	23.4	25.8	24.5
la	ICP-ES	µg/gm	121000	121000	113000	101000	115000	0	0	105385	85385	104000	104615	83846	106000	104615	85385
ld	ICP-ES	µg/gm	43	33.5	39.2	39	253.5	28.5	3.57	<7.692	10.2	2.32	<7.692	9.6	0.675	<7.692	9.1
i	ICP-ES	µg/gm	240	209	191	222	930	175	166	215	154	162	215	155	158	215	162
	ICP-ES	µg/gm	763	1050	345	974	2010	382	684	649	610	481	635	546	475	635	600
b	ICP-ES	µg/gm	106	80.7	86.8	85	397.0	75.3	5.13	<7.69	11.5	10.3	<7.69	11.7	19.3	<7.69	13.5
	ICP-ES	µg/gm	2580	2600	2700	2390	12700	2470	2450	2618	2385	2460	2585	2546	2400	2585	2485
i	ICP-ES	µg/gm	28	47.9	31.2	25	137	27.6	27.1	43.6	25.2	24.9	50.6	25.6	25.7	50.6	29.0
r	ICP-ES	µg/gm	26	57.4	24.8	4750	99.9	44.7	77.5	86.15	36.46	73.3	86.15	38.46	57.2	86.15	39.31
V	ICP-ES	µg/gm	98	85.3	97.1	91	477	86.9	86.9	88	82	87.1	85	82	86.2	85	87
n	ICP-ES	µg/gm	<10	<0.100	<0.100	<10	<0.100	<0.100	<0.100	<0.385	<0.008	<0.100	<0.385	<0.008	<0.100	<0.385	<0.008
r	ICP-ES	µg/gm	6.8	<0.100	2.26	5.9	1.14	1.81	<0.100	<0.769	1.79	<0.100	<0.769	1.75	<0.100	<0.769	1.85
	AAK	µg/gm	1110			1010											
la	AANA	µg/gm	126000			100000											
d	ICP-MS	µg/gm	36.1			26.5											
e	ICP-MS	µg/gm	27.1			24.4											
a	ICP-MS	µg/gm	23			21.1											
ld	ICP-MS	µg/gm	46.9			43.4											
b	ICP-MS	µg/gm	113			88.3											
Sample No.			185347	02-1545	02-1545	185348	02-1546	02-1546	02-1547	02-1227	02-1227	02-1548	02-1228	02-1228	02-1550	02-1229	02-1229
nalysis	Method	Units															
ree OH⁻	Titration	molar	0.964			0.882											
otal OH⁻	Titration	molar	2.62			2.05											
ther Base	Titration	molar	0.491			0.427											
hloride (Cl^-)	IC-Anion	µg/gm	2760		2424	2650		2323	2246		2269	2292		2338	2054		2308
luoride (F^-)	IC-Anion	µg/gm	1140		1193	988		1146	412		1023	411		1054	785		1054
ormate ($HCOO^-$)	IC-Anion	µg/gm	NA		5059	4250		4754	4546		4508	4562		4631	4115		4654
itrate (NO_3^-)	IC-Anion	µg/gm	104000		86838	94700		88462	85385		89231	85385		91538	77692		90000
itrite (NO_2^-)	IC-Anion	µg/gm	37200		34282	35200		32615	32231		34846	31538		35462	29000		34615
xalate ($C_2O_4^{2-}$)	IC-Anion	µg/gm	NA		<378	422		<385	474		838	<385		838	<385		<385
hosphate (PO_4^{3-})	IC-Anion	µg/gm	1970		2590	2080		2462	977		1531	877		1554	2146		1485
ulfate (SO_4^{2-})	IC-Anion	µg/gm	6900		7015	6090		6600	6308		6692	6277		6846	5831		6769
otal Carbon	TIC/TOC	µg/ml	19800			17800											
OC	TIC/TOC	µg/ml	11600			10700											
IC	TIC/TOC	µg/ml	8180			7130											

Sample Description			Batch 3B filtrate 3 hours after reagents added	Batch 3B precipitated simulant 4 hours after reagents added					Batch 3B precipitated simulant after Concentration in Crossflow			Filtered AN-102R2 filtrate composite tank final	Total AN-102R2 filtrate composite tank final	Total AN-102R2 filtrate composite tank final	Total AN-102R2 filtrate composite tank Day 1	Total AN-102R2 filtrate composite tank Day 2	Total AN-102R2 filtrate composit tank Day
EDL Sample No			3B-9L	3B-7SL	3B-10L	3B-10L			3B-8SL								
Time after Reagent Add (hrs)			3			4			16				27				
lensity		g/ml	1.26		1.30		1.31	1.31		1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.3
H		pH	10.5		10.6		10.3	10.3				10.8	10.8	10.8			
otal Solids		wt%	35.6				33.6										
oluble Solids		wt%	35.6				32.5										
nsoluble Solids		wt%	<0.100				1.04										
ADS or ML Sample No.			02-1970	185339	02-1858	02-1858 Rerun	02-1549	02-1549	185340	02-1639	02-1639	02-1226	02-1226	02-1554	02-1638	02-1633	02-1634
aterial submitted for ICP analysis			DE Filtrate	Slurry	DE Filtrate	DE Filtrate	Slurry	Slurry	Slurry	Slurry		XF Filtrate		XF Filtrate	XF Filtrate	XF Filtrate	XF Filtrat
Filtered by ADS or ML before ICP			No	No	No	No	No	Yes	No	No	Yes			No	No	No	No
nalysis	Method	Units															
l	ICP-ES	µg/gm	6510	6160	6170	6760	6010	5930	5920	4820	6130	7454	7108	9620	6862	6223	640
l	ICP-ES	µg/gm	28.9	18	19.4	26.3	20.8	21.8	16	20.2	31.7	68.0	49.5	31.0	23.1	21.4	21.
la	ICP-ES	µg/gm	0.110	33	<0.100	<0.100	26.3	<0.100	487	439.000	<0.100	<0.23	<0.38	<0.100	<0.01	<0.01	<0.0
a	ICP-ES	µg/gm	67.4	247	65.2	63.7	369	103	3120	3590	256	106	112	89.8	80	74	7
d	ICP-ES	µg/gm	23.7	20.0	16.1	19.6	16.9	15.4	56.0	20.6	<0.400	26.5	<1.15	30.2	21.5	21.4	21.
e	ICP-ES	µg/gm	<0.300	31	0.484	<0.100	23.1	1.0	325	341	<0.100	3.7	<12.31	0.133	3.1	4.4	6.
o	ICP-ES	µg/gm	<0.100	<2.0	<1.00	<1.00	<0.100	<0.100	26	14.0	<1.00	<0.01	<0.38	<1.00	<0.01	<0.01	<0.0
r	ICP-ES	µg/gm	102	108	94.2	103	93	78	148	97.1	21.9	114	112	129	99	95	9
u	ICP-ES	µg/gm	8.46	12	3.97	2.70	13.30	4.94	158	148	8.41	1.78	<3.85	2.77	2.66	2.53	2.6
e	ICP-ES	µg/gm	5.53	44	<0.200	<0.200	25.0	<0.200	506	372	51.1	0.6	42.6	<0.200	0.5	1.5	2
	ICP-ES	µg/gm	2090	1160	2150	2150	2080	2100	946	1640	2380	1977	2575	3520	2423	2185	224
a	ICP-ES	µg/gm	<0.100	20	<0.400	<0.400	18.8	<0.400	282	281	1.35	2.3	<3.846	<0.400	2.7	4.3	7.
Mg	ICP-ES	µg/gm	<0.040	12	<0.100	<0.100	<0.100	<0.100	175	128	<0.100	<0.031	<1.538	<0.100	<0.008	<0.008	<0.0C
Mn	ICP-ES	µg/gm	0.945	2060	<0.100	<0.100	1950.0	<0.100	30300	26000	<0.100	5.4	<0.385	4.05	5.0	4.2	5.
Mo	ICP-ES	µg/gm		21.6		23.4			19.3			23.5	26.2	28.9	0	0	
la	ICP-ES	µg/gm	70100	94200	107000	105000	105000	105000	104000	107000	133000	100769	104615	130000	121538.5	112307.7	109230
ld	ICP-ES	µg/gm	0.569	29	0.601	<0.100	32.4	0.6	532	482	<0.100	6.2	<7.7	1.82	4	5	
i	ICP-ES	µg/gm	158	215	141	161	163	139	653	523	167	153	218	194	153.8	147.7	150
	ICP-ES	µg/gm	476	930	776	546	667	626	2780	2430	438	629	583	1080	823	748	76
b	ICP-ES	µg/gm	23.8	79	21.8	22.8	70.7	15.4	1030	830	<0.100	15.6	<7.7	26.3	18	17	1
	ICP-ES	µg/gm	2400	2330	2020	2440	1880	1900	1990	1650	2410	2292	2640	3350	2200.0	2038.5	2138
i	ICP-ES	µg/gm	22.4	21	23.1	26.2	25.7	23.9	547	74.1	75.4	26.5	108.5	30.1	24	23	2
r	ICP-ES	µg/gm	54.3	4530	51.6	48.3	5410.00	50.50	70700	55900	56.10	19.23	29.85	70.8	62.6	60.1	60.
V	ICP-ES	µg/gm	89.2	85	83.1	87.2	82	83	89	86.9	114	85	90	108	86.15	83.08	84.6
n	ICP-ES	µg/gm	20.8	<10	<0.100	<0.100	<0.100	<0.100	23	<0.100	<0.100	<0.008	<0.385	<0.100	1	1	
r	ICP-ES	µg/gm	0.417	6.3	<0.100	<0.100	2.16	<0.100	74	63.80	1.52	1.57	<0.769	<0.100	0.65	0.70	1.C
	AAK	µg/gm		988					852.6								
la	AANA	µg/gm		90000					100358.5								
d	ICP-MS	µg/gm		21					59								
e	ICP-MS	µg/gm		23.2					325								
a	ICP-MS	µg/gm		20.1					293								
ld	ICP-MS	µg/gm		41.3					571								
b	ICP-MS	µg/gm		79.9					1100								
Sample No.			02-1970	185349	02-1858	02-1858 Rerun	02-1549	02-1549	185350	02-1639	02-1639	02-1226	02-1226	02-1554	02-1638	02-1633	02-1634
nalysis	Method	Units															
ree OH⁻	Titration	molar		0.767													
otal OH⁻	Titration	molar		2.04													
ther Base	Titration	molar		0.408													
hloride (Cl^-)	IC-Anion	µg/gm	2302	2420	2223			2023			1831	2295	2295	2185	2215	2200	220
luoride (F^-)	IC-Anion	µg/gm	445	680	531			779			1777	1008	1008	823	377	422	4C
ormate ($HCOO^-$)	IC-Anion	µg/gm	4625	3880	4554			4076			4508	4615	4615	4508	4546	4492	433
itrate (NO_3^-)	IC-Anion	µg/gm	85714	87500	97692			80153			71846	90000	90000	83077	83846	83846	8307
itrite (NO_2^-)	IC-Anion	µg/gm	31587	32500	35692			29160			27077	34615	34615	31077	31538	31231	3153
xalate ($C_2O_4^{2-}$)	IC-Anion	µg/gm	<79	1400	<385			1069			1523	823	823	1185	704	742	83
hosphate (PO_4^{3-})	IC-Anion	µg/gm	1087	1920	2231			2137			1877	1377	1377	2015	1323	1454	152
ulfate (SO_4^{2-})	IC-Anion	µg/gm	6524	5690	6354			5779			5608	6692	6692	6308	6269	6215	623
otal Carbon	TIC/TOC	µg/ml		17100													
OC	TIC/TOC	µg/ml		9830													
IC	TIC/TOC	µg/ml		7270													

				Solids Analysis					
Sample Description			OPTIMA input into AN-102R2	AN-102R2 simulant at 6.5M Na before aging	AN-102R2 simulant at 6.5M Na after aging 1 week	AN-102R2 simulant at 6.5M Na after aging 1 week	AN-102R2 simulant after dilution and solids	Post-Filtration Solids	Post-Filtration Solids
Time after Reagent Add (hrs)				N/A	N/A	N/A	N/A	50	>50
EDL Sample									
Mobile Lab Sample No.			02-9559	02-9558	02-9668	02-1552	02-1190	02-1833	02-1640
	Units	Method							
Sample quanity	grams			0.7678				0.5817	
Al	µg/gm	ICP-ES	5320	6640	7842	46400	7400	3740	6700
B	µg/gm	ICP-ES	344	47.2	31.5	143	38.3	41.5	25.0
Ba	µg/gm	ICP-ES	81.4	11.7	<0.010	<0.100	<0.500	<0.100	<0.100
Ca	µg/gm	ICP-ES	12600	2040	379	40500	258	50.2	70.9
Cd	µg/gm	ICP-ES	<10.0	<10.0	35	<0.400	9.51	<0.100	19.0
Ce	µg/gm	ICP-ES	<10.0	110	20.3	663	15.4	<0.100	<0.100
Co	µg/gm	ICP-ES	<10.0	<10.0	<0.010	116	<0.500	<0.100	<1.00
Cr	µg/gm	ICP-ES	325	54.4	124	1000	122	52.7	101
Cu	µg/gm	ICP-ES	456	107	14.4	693	12.3	13.2	2.26
Fe	µg/gm	ICP-ES	1460	193	29.4	6400	38.7	<0.100	<0.200
K	µg/gm	ICP-ES	953	316	2670	2150	2550	1620	2140
La	µg/gm	ICP-ES	602	250	13.9	2930	5.8	<0.100	<0.400
Mg	µg/gm	ICP-ES	3370	289	<0.010	7450	<0.500	<0.100	<0.100
Mn	µg/gm	ICP-ES	335	47.5	22.2	4930	2.9	<0.100	<0.100
Mo	µg/gm	ICP-ES	139	21.9	27.4	3.68	19.5		23.2
Na	µg/gm	ICP-ES	177000	54400	109000	156000	103000	166000	104000
Nd	µg/gm	ICP-ES	<10.0	286	30.9	2190	28.8	<0.100	<0.100
Ni	µg/gm	ICP-ES	3490	326	203	7850	216	81.1	156
P	µg/gm	ICP-ES	40900	12000	587	20800	1080	38900	835
Pb	µg/gm	ICP-ES	507	324	91.8	2720	99.5	6.68	18.9
S	µg/gm	ICP-ES	<500	440	3180	3250	2550	1470	2430
Si	µg/gm	ICP-ES	382	105	25.6	1120	11	59.7	26.4
Sr	µg/gm	ICP-ES	232	27.4	53.7	9660	<0.500	63.7	55.0
W	µg/gm	ICP-ES	<500	43.6	104	363	108	62.2	85.4
Zn	µg/gm	ICP-ES	<10.0	34.5	<0.010	649	<0.500	<0.100	<0.100
Zr	µg/gm	ICP-ES	250	74.6	6.17	315	14.9	<0.100	<0.100
Chloride (Cl^-)	µg/ml	ICA						1350	2920
Fluoride	µg/ml	ICA						12300	534
Formate ($HCOO^-$)	µg/ml	ICA						2720	6000
Nitrate (NO_3^-)	µg/ml	ICA						49100	111000
Nitrite (NO_2^-)	µg/ml	ICA						17500	40900
Oxalate ($C_2O_4^{2-}$)	µg/ml	ICA						20900	815
Phosphate (PO_4^{3-})	µg/ml	ICA						97300	1780
Sulfate (SO_4^{2-})	µg/ml	ICA						4030	8290

SRT-ADS-02-0594

Discussion of Results

One sample ADS 3-186617 (RPP-WTP-PREC3B-1VOA) was submitted for volatile organic compound (VOC) and permanent gas analysis. The detection limit for permanent gases was 0.1%, and for VOC analysis was 0.1 ppmv for this study. Results are tabulated below.

Analyte	Concentration
Oxygen	21%
Nitrogen	76%
Hydrogen	< 0.1 %
D-Limonene	0.20 ppmv

Experimental - VOA

The sample was analyzed by purge and trap Gas Chromatography / Mass Spectrometry (GC/MS).
GC/MS analysis was employed to identify organic compounds in the samples. Analysis were carried out in building 773-A, laboratory B-159.
It should be noted that ADS is not certified by DHEC for NPDES discharge compliance monitoring.
Analytical separations were carried out on a Hewlett Packard 6890 gas chromatograph, equipped with a 20 m DB-624 column, with 0.18 mm diameter and 1.0 um film thickness. Quantitation was performed using a Hewlett Packard 5973 mass selective detector. The mass spectrometer tuning was confirmed within 24 hours prior to each measurement using perfluorotributylamine.

Experimental - permanent gas analysis

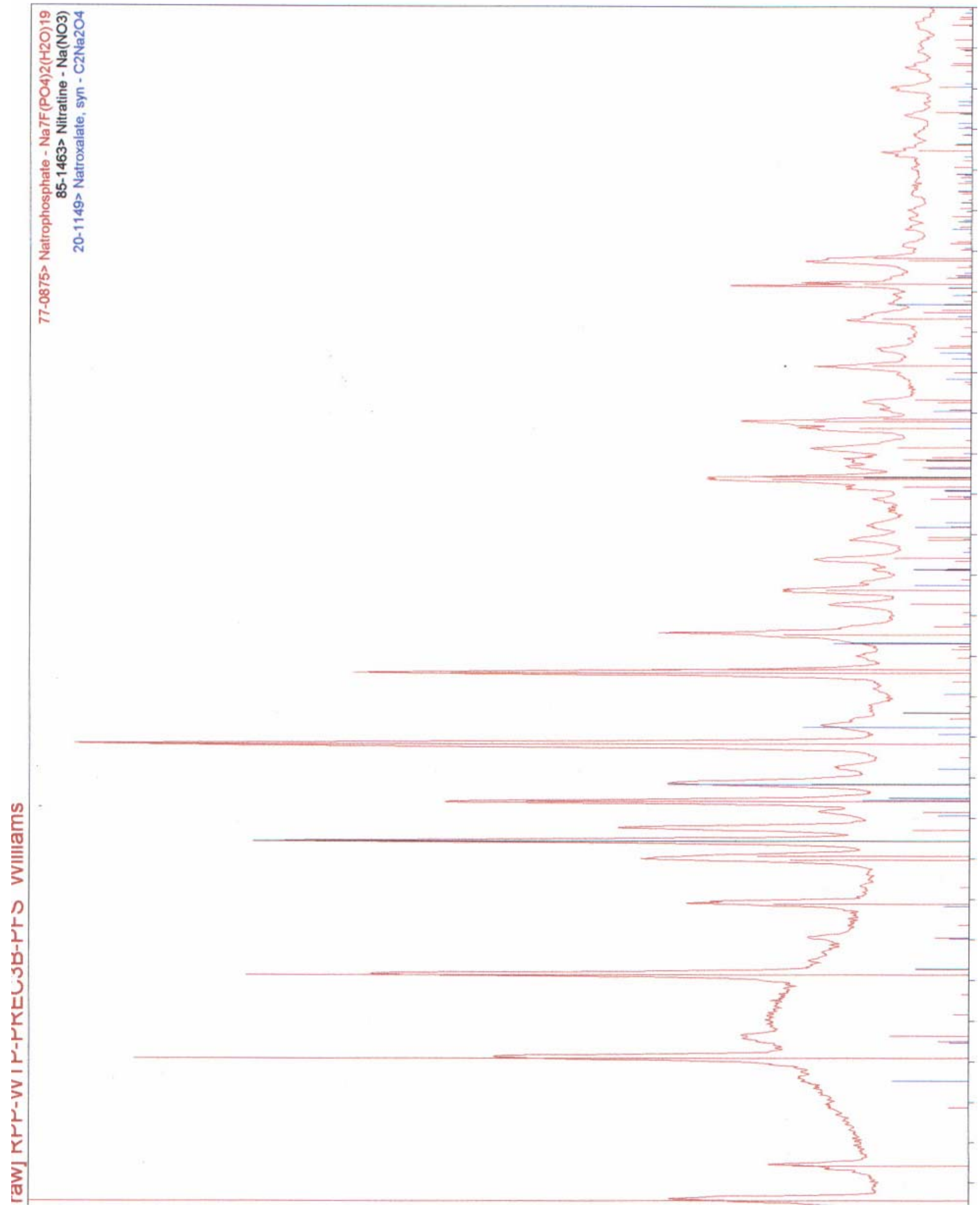
Permanent gas analysis were carried out on a Hewlett Packard model 5890 gas chromatograph (GC) equipped with a molecular sieve column and thermal conductivity detector (TCD). Calibration was carried out prior to and after the sample analyses using Scott Gas Mix 218, as well as calibration verification using blank air. Samples were run in duplicate for confirmation of results.

Lasentec Data

At 1635 hours on 10/22/02, a Batch 3B filtrate sample was taken from the Cross-flow Test Rig filtrate line five hours after reagents were added. The Lasentec measured 20.6 microns mean chord length at 36.5 counts/sec, 19.1 microns at 2.1 counts/sec, 19.6 microns at 33.0 counts/sec, 19.03 microns at 50.7 counts/sec, 18.68 microns at 13 counts/sec, and 19.58 microns at 11.8 counts/sec. These readings included air bubbles in the sample. Another sample was taken and air bubbles allowed to dissipate. After a few minutes, the Lasentec measured 19.0 microns at 0.8 counts/sec and 18.6 microns at 0.8 counts/sec.

At 1523 hours on 10/23/02, a composite filtrate sample from 1100 hours (29 hrs after reagent addition) was allowed to dissipate air bubbles while the prior collected sample was re-measured. The Lasentec measured 11 microns at about 17 counts/sec on the re-measured sample. The composite filtrate sample measured less than 20 microns at just slightly above background counts/sec.

At 0800 hours on 10/28/02 (142 hrs ARA), the composite filtrate tank was agitated and a 300 ml sample was taken for Lasentec measurement. A blank sample of 0.01 micron DIF water was first tested and found to indicate 5 or less counts/sec in the 0-30 micron range. The filtrate sample had a mean chord length of about 16 microns at about 190 counts/sec for four successive measurements. Each measurement had a sharp peak at about 12 microns. The sharp peak at 12 microns disappeared after cleaning the Lasentec measuring head with 6M sulfuric acid. Another sample was taken from the composite filtrate tank and the Lasentec did not measure the 12 micron peak. The Lasentec measured 16.1 microns at 195.3 counts/sec, 16.7 microns at 178.8 counts/sec, 14.4 microns at 159.7 counts/sec, 16.0 microns at 204.4 counts/sec, 13.6 microns at 171.9 counts/sec, and 13.7 microns at 167.6 counts/sec. The distribution was bimodal with peaks at 6 and 20 microns.


raw] RPP-WTP-PREC3B-PPS Williams
77-0875> Natrophosphate - Na7F(PO4)2(H2O)19
85-1463> Nitratine - Na(NO3)
20-1149> Natroxalate, syn - C2Na2O4

APPENDIX G

Batch 3A Analytical Data

Appendix Contents

- Liquid, Solid, and Gas Sample Analyses
- Lasentec Data
- Post-Filtration XRD

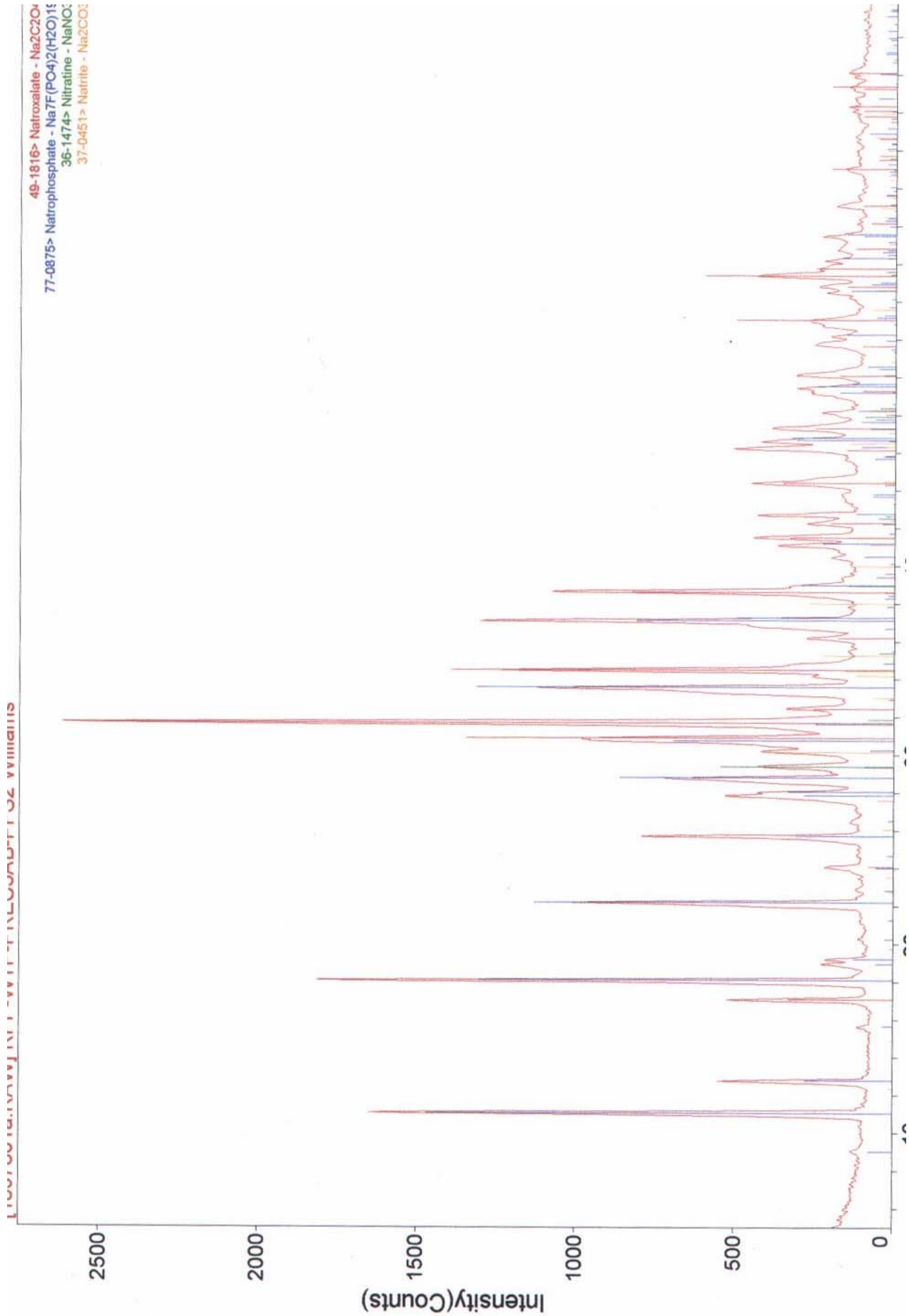
Special Notes:

- Each Solid Sample was divided into four segments for various dissolutions and analyses.
- < values indicate below detection limits.
- Lasentec samples were taken at ten hours, 14 hours, twenty hours and twenty-eight hours after reagents were added.
- The identification of materials by the X-ray Diffraction (XRD) method was performed in accordance with the International Center for Diffraction Data at www.icdd.com using the Powder Diffraction Database of PDF cards.

BATCH 3A ANALYSIS																									
Sample Description			AN-102R2 simulant at 6.5 M Na before aging		AN-102R2 simulant at 6.5M Na after aging 1 week	AN-102R2 simulant at 6.5 M Na after aging 1 week (added remaining 118.5 kg of 3B simulant to 867.7 kg of 3A simulant)			AN-102R2 simulant at 6.0 M Na with solids		AN-102R2 simulant after 0.8 M caustic add			AN-102R2 simulant after 0.075M Sr(NO3)2		AN-102R2 filtrate 7.5 min. after reagents added	AN-102R2 filtrate 15 min. after reagents added	AN-102R2 filtrate 30 min. after reagents added	AN-102R2 filtrate 1 hr. after reagents added	AN-102R2 filtrate 2 hrs after reagents added	AN-102R2 filtrate 3 hrs after reagents added	AN-102R2 slurry 4 hrs after precip	Total AN-102R2 filtrate 4 hrs after reagents added	Filtered AN-102R2 slurry 5 hrs after reagents added	Total AN-102R2 slurry 5 hrs after reagents added
EDL Sample No.			3A-1SL		3A-2SL	3A-0S/L			3A-1S/L		3A-4SL	3A-2S/L		3A-5SL	3A-3L	3A-4L	3A-5L	3A-6L	3A-7L	3A-8L	3A-9L	3A-6SL	3A-10L	3A-SL1	
Time after Reagent Add (hrs)			N/A		N/A		N/A		N/A			N/A		N/A		0.125	0.25	0.5	1	2	3	4		5	
Density		g/ml		1.320	1.32	1.32	1.35	1.35	1.36	1.36		1.31	1.31			1.29		1.29		1.29			1.29	1.25	1.25
pH		pH		10.5		11.3	10.8	10.8	10.5	10.5		10.5	10.5			10.5		10.5		10.5			10.4	10.5	10.5
Total Solids		wt%		35.7		35.7		40.1		34.0			36.0												33.2
Soluble Solids		wt%		35.4		35.5		34.0		34.0			35.3												32.5
Insoluble Solids		wt%		0.359		0.207		0.620		<0.100			0.621												0.670
ADS or ML Sample No.			185312	02-9466	185313	02-9603	02-1551	02-1551	02-1553	02-1553	185315	02-1555	02-1555	185316		02-1861		02-1862		02-1863		185317	02-1859	02-1860	02-1860
Material submitted for ICP analysis			Slurry	Slurry	Slurry	Slurry	Slurry		Slurry		Slurry	Slurry		Slurry	DE Filtrate	DE Filtrate	DE Filtrate	DE Filtrate	DE Filtrate	DE Filtrate	DE Filtrate	Slurry	DE Filtrate	Slurry	
Filtered by ADS or ML before ICP			No	Yes	No	Yes	Yes	No	Yes	No	No	Yes	No	No		No		No		No		No	No	Yes	No
Analysis	Method	Units																							
Al	ICP-ES	µg/gm	7390	6900	7400	7730	8260	7440	6800	6760	6920	7590	7580	6530	S	6750	S	6730	S	6540	S	6220	6080	6040	5910
B	ICP-ES	µg/gm	19	29.6	31	27.9	32.4	30.9	23.9	23.7	19.0	28.7	28.9	17.0	A	26.1	A	25.6	A	25.3	A	17.0	18.8	19.2	18.5
Ba	ICP-ES	µg/gm	0.52	<0.010	<1.0	0.328	<0.100	<0.100	<0.100	<0.100	2.6	<0.100	<0.100	38.0	M	<0.100	M	<0.100	M	<0.100	M	25	<0.100	<0.100	31.1
Ca	ICP-ES	µg/gm	329	299	250	339	341	772	297	375	239	305	352	241	P	60.7	P	52.1	P	56.0	P	176	61.0	70.9	351
Cd	ICP-ES	µg/gm	37	29.2	38	25.0	28.8	24.5	20.7	21.8	35.0	25.3	25.3	32.0	L	17.9	L	17.5	L	17.7	L	31.0	14.8	14.8	16.5
Ce	ICP-ES	µg/gm	28	21.7	24	22.7	23.8	21.5	23.7	24.7	26.0	20.8	21.4	29.0	E	3.67	E	1.38	E	1.46	E	20.0	3.34	3.32	23.0
Co	ICP-ES	µg/gm	2.3	0.841	2.6	1.30	<0.100	<0.100	<1.00	<1.00	<2.0	<1.00	<1.00	2.3		<1.00		<1.00		<1.00		1.40	<1.00	<1.00	<1.00
Cr	ICP-ES	µg/gm	126	117	126	114	127	115	103	109	118	114	116	112	A	102	A	101.0	A	101.0	A	106	92.7	91.9	92.5
Cu	ICP-ES	µg/gm	14.8	7.33	15.8	6.90	7.74	15.1	13.9	14.9	14.0	13.7	14.4	13.0	R	1.68	R	0.888	R	0.890	R	8.60	2.16	2.71	13.6
Fe	ICP-ES	µg/gm	41.2	25.3	44.1	22.7	27.5	46.1	30.9	44.2	54.0	28.9	34.9	40.0	C	<0.200	C	0.636	C	0.874	C	31.0	0.306	2.82	29.7
K	ICP-ES	µg/gm	1330	1920	1280	2430	2580	2350	2280	2280	1270	2380	2380	1190	H	2130	H	2170	H	2090	H	1180	2080	2070	2060
La	ICP-ES	µg/gm	<25	20.2	23	20.6	16.9	19.1	17.8	21.2	21.0	15.0	17.4	21.0	I	<0.400	I	<0.400	I	<0.400	I	15.0	1.48	1.22	18.7
Mg	ICP-ES	µg/gm	18.7	0.402	15	0.473	<0.100	6.22	<0.100	3.13	16.0	<0.100	3.10	14.0	V	<0.100	V	<0.100	V	<0.100	V	9.00	<0.100	<0.100	<0.100
Mn	ICP-ES	µg/gm	18.2	14.1	19	12.3	8.77	36.2	9.01	24.9	33.0	7.61	24.6	29.0	E	<0.100	E	<0.100	E	<0.100	E	1360	<0.100	0.19	1850
Mo	ICP-ES	µg/gm	30.0	23.9	30	22.3	29.1	25.5			25.7	25.9	26.3	23.0	D	23.2	D	23.3	D	23.3	D	23.0			
Na	ICP-ES	µg/gm	109000	102000	110000	108000	105000	119000	104000	104000	121000	112000	112000	110000		105000		102000		104000		108000	104000	103000	103000
Nd	ICP-ES	µg/gm	21	25.3	29	27.3	30.4	28.2	25.2	26.6	28.0	26.3	27.8	28.0	O	8.51	O	6.20	O	5.44	O	27.0	5.04	4.29	23.2
Ni	ICP-ES	µg/gm	255	195	253	192	219	208	174	188	240	196	212	220	N	167	N	163	N	163	N	203	143	140	162
P	ICP-ES	µg/gm	1030	567	729	564	453	7598	454	968	918	351	683	657	L	658	L	738	L	695	L	727	560	420	618
Pb	ICP-ES	µg/gm	111	51.7	115	50.7	76.4	89.3	73.9	78.2	107.0	87.6	91.4	99.0	Y	10.6	Y	7.34	Y	7.42	Y	69.0	8.95	14.3	70.0
S	ICP-ES	µg/gm	2770	2420	2700	2640	2860	2640	2160	2170	2560	2670	2610	2400		2390		2290		2270		2340	1920	1920	1880
Si	ICP-ES	µg/gm	25	32.3	35	29.9	30.9	40.2	37.3	40.2	25.0	33.5	32.4	22.0		25.9		25.7		25.6		21.0	23.1	26.0	26.6
Sr	ICP-ES	µg/gm	3.1	0.396	3.0	4.53	11.7	194	13.2	71.3	37.0	10.4	66.6	5220		162		162		151		3450	132	104.0	6150
W	ICP-ES	µg/gm		99.2		76.5	106	93.9	92.1	92.5	96.0	96.5	96.1	88.0		85		83.2		83.4		85.0	80.6	80.8	80.9
Zn	ICP-ES	µg/gm	<15	1.42	<10	4.18	<0.100	<0.100	<0.100	<0.100	<10	<0.100	<0.100	<10		<0.100		<0.100		<0.100		<10	<0.100	<0.100	<0.100
Zr	ICP-ES	µg/gm	7.2	6.93	1.4	6.98	3.42	2.73	2.41	3.23	6.80	2.62	3.29	6.10		<0.100		<0.100		<0.100		4.30	<0.100	<0.100	2.01
K	AAK	µg/gm	236.4		1261.4						1160			1040								1000			
Na	AANA	µg/gm	104833.4		110937.1						124000			110000								113000			
Cd	ICP-MS	µg/gm	37.8		36.9						35.3			32.4								30.1			
Ce	ICP-MS	µg/gm	27.0		26.4						25.7			23.5								16.3			
La	ICP-MS	µg/gm	23.6		22.4						22.1			20.5								14.1			
Nd	ICP-MS	µg/gm	32.5		31.8						32.7			30								21.9			
Pb	ICP-MS	µg/gm	118		113						111			102								70.9			
Sample No.			185322	02-9466	185323	02-9603	02-1551	02-1551	02-1553	02-1553	185325	02-1555	02-1555	185326		02-1861		02-1862		02-1863		185327	02-1859	02-1860	02-1860
Analysis	Method	Units																							
Free OH-	Titration	molar	0.271		0.267						1.02			0.948								0.865			
Total OH-	Titration	molar	1.62		1.65						2.25			2.21								2.09			
Other Base	Titration	molar	0.53		0.52									0.427								0.432			
Chloride (Cl^-)	IC-Anion	µg/gm	2960	2800	3020	2591	2420		2162		25	2477		2760		2248		2225		2240		2540	2225	2280	
Fluoride (F^-)	IC-Anion	µg/gm	1190	698	1190	1129	1633		1132		<19	<405		952		<388		<388		<388		600	462	426	
Formate ($HCOO^-$)	IC-Anion	µg/gm	4970	5570	5040	5091	5345		4860		NA	4970		4140		4380		4333		4256		3650	4256	4424	
Nitrate (NO_3^-)	IC-Anion	µg/gm	115000	104000	111000	105303	92799		83824		1140	87169		93600		86822		87597		86822		86000	84496	85600	
Nitrite (NO_2^-)	IC-Anion	µg/gm	46600	41300	46900	38939	37120		33750		411	34944		37400		32016		31860		31860		34600	30930	31840	
Oxalate ($C_2O_4^{2-}$)	IC-Anion	µg/gm	335	260	343	<758	<371		<368		NA	<382		444		<388		<388		<388		1590	1310	872	
Phosphate (PO_4^{3-})	IC-Anion	µg/gm	3240	1490	3340	1523	802		2066		<93	2883		3660		1457		2109		1558		2700	1411	1288	
Sulfate (SO_4^{2-})	IC-Anion	µg/gm	9580	7850	8900	7576	7283		6581		67	6996		5930		6279		6310		6279		5490	6202	6392	
Total Carbon	TIC/TOC	µg/ml	20700		21000						19600			18000								18700			
TOC	TIC/TOC	µg/ml	12100		12400						11500			11000								10600			
TIC	TIC/TOC	µg/ml	8600		8600						8140			7030								8120			

BATCH 3A ANALYSIS						
			Solids Analysis			
Sample Description			AN-102R2 simulant at 6.5M Na before aging	Filtered AN-102R2 simulant at 6.5M Na after aging 1 week	Filtered AN-102R2 simulant after dilution and solids	Post Filtration Solids
Time after Reagent Add (hrs)			N/A	N/A	N/A	
EDL Sample						
Mobile Lab Sample No.			02-9466	02-9603	02-1641	03-0913
Identity	Units	Method				
Sample quanity	grams		0.1328			
Al	ηg/gm	ICP-ES	2370	8840	5810	2380
B	ηg/gm	ICP-ES	69.3	373	172	219
Ba	ηg/gm	ICP-ES	<1.00	60.6	<0.100	<0.200
Ca	ηg/gm	ICP-ES	5080	5520	7570	50.0
Cd	ηg/gm	ICP-ES	<1.00	<10.0	<0.400	<0.300
Ce	ηg/gm	ICP-ES	20.0	116	<0.100	
Co	ηg/gm	ICP-ES	30.1	170	<1.00	
Cr	ηg/gm	ICP-ES	97.9	300	<0.100	34.3
Cu	ηg/gm	ICP-ES	65.5	434	128	3.45
Fe	ηg/gm	ICP-ES	260	1310	931	197
K	ηg/gm	ICP-ES	573	1180	1140	785
La	ηg/gm	ICP-ES	84.3	497	48.9	
Mg	ηg/gm	ICP-ES	350	2300	767	<0.400
Mn	ηg/gm	ICP-ES	70.0	281	1140	7.43
Mo	ηg/gm	ICP-ES	48.9	145	<0.100	
Na	ηg/gm	ICP-ES	208000	173000	426000	200000
Nd	ηg/gm	ICP-ES	63.2	458	<0.100	
Ni	ηg/gm	ICP-ES	338	2420	1350	39.2
P	ηg/gm	ICP-ES	64000	41200	95100	87800
Pb	ηg/gm	ICP-ES	98.6	523	143	8.49
S	ηg/gm	ICP-ES	1220	1930	1930	
Si	ηg/gm	ICP-ES	297	448	558	280
Sr	ηg/gm	ICP-ES	202	<10.0	4070	123
W	ηg/gm	ICP-ES	80	<10.0	<0.100	
Zn	ηg/gm	ICP-ES	<1.00	114	<0.100	<0.100
Zr	ηg/gm	ICP-ES	246	235	<0.100	11.9
Chloride (Cl^-)	ηg/gm	ICA	1100			
Fluoride (Fl^-)	ηg/gm	ICA	18500			
Formate ($HCOO^-$)	ηg/gm	ICA	2170			
Nitrate (NO_3^-)	ηg/gm	ICA	29700			
Nitrite (NO_2^-)	ηg/gm	ICA	12000			
Oxalate ($C_2O_4^{2-}$)	ηg/gm	ICA	<1000			
Phosphate (PO_4^{3-})	ηg/gm	ICA	187000			
Sulfate (SO_4^{2-})	ηg/gm	ICA	4600			

BATCH 3A ANALYTICAL RESULTS											
							Batch 3A Solids Analysis				
Description of Mobile Lab Solid Sample microwave dried at 150C overnight			AN-102R2 simulant at 6.5M Na before aging	AN-102R2 simulant at 6.5M Na before aging	AN-102R2 simulant at 6.5M Na after aging 1 week	AN-102R2 simulant at 6.5M Na after aging 1 week	AN-102R2 simulant at 6.5M Na after aging 1 week	AN-102R2 simulant after dilution and solids	AN-102R2 simulant after caustic add	AN-102R2 slurry 4 hours after reagents added	AN-102R2 slurry 5 hours after reagents added
Identity	Units	Method	02-9466A	02-9466B	02-9603A	02-9603B	02-1551	02-1553	02-1555	02-1859	02-1860
Empty Crucible Wt.	grams	scale	44.1844	44.8115							
Crucible Wt. + Wet Sample	grams	scale	57.0191	57.779							
Crucible Wt. + Dry Wt.	grams	scale	48.7588	49.4483							
Total Solids	%		35.6	35.8	35.7	35.7	40.1	34	36	NR	33.2
Wet Weight	grams	scale	12.8347	12.9675							
Dry Weight	grams	scale	4.574	4.637							
Insoluble Solids	%		0.511	0.206	0.206	0.208	6	<0.100	0.621	NR	0.67
Empty Crucible Wt.	grams	scale	43.5298	42.4391							
Crucible Wt. + Wet Sample	grams	scale	49.5552	48.8381							
Crucible Wt. + Dry Wt.	grams	scale	45.6574	44.7187							
Uncorrected	%		35.31	35.6							
Soluble Solids	%		35.1	35.6	35.5	35.5	34	34	35.3	NR	32.5
NR=Not Required											


49-1816> Natroxalate - Na2C2O
77-0875> Natrophosphate - Na7F(PO4)2(H2O)1
36-1474> Nitratine - NaNO
37-0451> Natrite - Na2CO
Intensity(Counts)
2500
2000
1500
1000
500
0

Lasentec Data

At 1025 hours on 11/13/02 (169 hrs after reagent addition), a 300 ml sample was taken for Lasentec measurement from the Composite Filtrate Carboy after shaking it well. Measurements were 13.09 microns mean chord length at 12.36 counts/sec, 13.03 microns at 12.49 counts/sec, 12.93 microns at 12.01 counts/sec and 13.04 microns at 11.89 counts/sec. The Lasentec was checked before and after these measurements with 0.01 micron filtered de-ionized water (DIF).

At 0816 hours on 11/20/02 (335 hrs ARA), the Lasentec probe was cleaned and 0.01 micron DIF water was measured. The measurement was 1 to 5 counts/sec in the 1 to 30 micron range. A 300 ml sample was measured by the Lasentec. Measurements were 13.98 micron mean chord length at 47.61 counts/sec, 13.18 microns at 47.78 counts/sec, 13.58 microns at 46.78 counts/sec, and 13.4 microns at 45.62 counts/sec. All counts were very low.

APPENDIX H

Batch 4A Analytical Data

<u>Appendix Contents</u>

- Liquid, Solid, and Gas Sample Analyses
- Post-Filtration XRD

Special Notes:

- Each Solid Sample was divided into four segments for various dissolutions and analyses except the post-filtration solids which were not subdivided due to their small quantity.
- < values indicate below detection limits.
- The identification of materials by the X-ray Diffraction (XRD) method was performed in accordance with the International Center for Diffraction Data at www.icdd.com using the Powder Diffraction Database of PDF cards.

BATCH 4A ANALYSIS																
Sample Description			AN-102R2 simulant at 6.5 M Na before aging		AN-102R2 simulant at 6.5 M Na after aging 1 week		AN-102R2 simulant after dilution and solids	AN-102R2 simulant after caustic addition	AN-102R2 simulant after $Sr(NO_3)_2$ addition	AN-102R2 simulant 30 min. after $NaMnO_4$ addition	AN-102R2 simulant 1 hour after $NaMnO_4$ addition	AN-102R2 simulant 2 hours after $NaMnO_4$ addition	AN-102R2 simulant 3 hours after $NaMnO_4$ addition	AN-102R2 simulant 4 hours after $NaMnO_4$ addition	AN-102R2 simulant after 18 hour cool down
EDL Slurry Sample			4A-1SL	4A-1L	4A-2SL	4A-2L	4A-3L	4A-4L	4A-5L	4A-6L	4A-7L	4A-8L	4A-9L	4A-10L	4A-11L
Time after Reagent Add (hrs)			N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.5	1	2	3	4	22
Density		g/ml		1.29		1.32	1.28	1.31	1.28	1.28	1.28	1.28	1.28	1.28	1.28
pH		pH		10.6		10.8									
Total Solids		wt%		35.1		35.6	35.2			34.5		34.5		34.4	35.0
Soluble Solids		wt%		35.1		35.6	35.1			33.5		33.6		33.7	33.9
Insoluble Solids		wt%		<0.100		<0.100	0.100			1.00		0.900		0.700	1.10
ADS or ML Sample No.			189211	02-1948	189212	02-1966	03-0579			03-0580		03-0581		03-0582	03-0583
Material submitted for ICP Analysis			Slurry	DE Filtrate	Slurry	DE Filtrate	DE Filtrate	DE Filtrate	DE Filtrate	DE Filtrate	DE Filtrate	DE Filtrate	DE Filtrate	DE Filtrate	DE Filtrate
Filtered by ADS or ML before ICP			No	No	No	No	No			No		No		No	No
Analysis	Method	Units													
Al	ICP-ES	µg/gm	7360	7570	7180	7690	7097	S	S	6487	S	6538	S	6582	7378
B	ICP-ES	µg/gm	29	34.6	24	35.2	26.2	T	T	23.2	T	24.0	T	23.6	32.0
Ba	ICP-ES	µg/gm	<1.0	<0.100	<1.0	0.192		A	A		A		A		
Ca	ICP-ES	µg/gm	252	344	278	314	348	B	B	102	B	108	B	105	53.8
Cd	ICP-ES	µg/gm	37	20.8	37	30.5		I	I		I		I		
Ce	ICP-ES	µg/gm	28	24.9	28	21.9	17.8	L	L	2.71	L	1.97	L	1.50	1.53
Co	ICP-ES	µg/gm	2.7	<1.00	2.7	0.860		I	I		I		I		
Cr	ICP-ES	µg/gm	140	119	138	133	103	Z	Z	92.0	Z	94.0	Z	93.7	106
Cu	ICP-ES	µg/gm	15	13.4	14	17.6	18.3	E	E	1.76	E	3.52	E	5.30	7.97
Fe	ICP-ES	µg/gm	39	25	39	27.3	18.3	D	D	0.943	D	0.807	D	0.890	0.875
K	ICP-ES	µg/gm	1340	2490	1350	2450	1894			1778		1777		1780	1798
La	ICP-ES	µg/gm	23	15.1	22	15.5	16.4	A	A	1.22	A	0.846	A	0.625	0.672
Mg	ICP-ES	µg/gm	15	<0.100	15	<0.040	<0.031	N	N	<0.031	N	<0.031	N	<0.031	<0.031
Mn	ICP-ES	µg/gm	25	8.65	25	14.2	13.6	D	D	7.12	D	9.47	D	11.6	13.0
Mo	ICP-ES	µg/gm	29	22.6	28	30.4	19.7			17.9		18.2		18.1	21.3
Na	ICP-ES	µg/gm	111000	115000	110000	70000	101721	A	A	78752	A	102576	A	102280	0
Nd	ICP-ES	µg/gm	47	37.8	47	36.5	30.8	R	R	4.28	R	2.87	R	2.16	2.12
Ni	ICP-ES	µg/gm	253	187	246	205	112	C	C	92.8	C	94.0	C	95.3	109
P	ICP-ES	µg/gm	959	415	1070	462	915	H	H	811	H	822	H	820	868
Pb	ICP-ES	µg/gm	114	79.6	107	89.1	48.5	I	I	5.64	I	9.32	I	10.0	10.1
S	ICP-ES	µg/gm	2770	2640	2690	2920	2621	V	V	2370	V	2420	V	2358	2345
Si	ICP-ES	µg/gm	25	24.7	23	25.0	27.7	E	E	22.1	E	23.1	E	22.5	28.3
Sr	ICP-ES	µg/gm	22	19.2	27	28.5	30.3	D	D	112	D	86.9	D	72.1	76.6
W	ICP-ES	µg/gm	102	96.4	104	105									
Zn	ICP-ES	µg/gm	<10	<0.100	<10	3.94	5.35	O	O	4.37	O	3.98	O	3.86	4.47
Zr	ICP-ES	µg/gm	7.6	0.237	7.8	7.29	5.57	N	N	1.33	N	1.06	N	0.98	1.06
K	AAK	µg/gm	1180		1169			L	L		L		L		
Na	AANA	µg/gm	103000		103000			Y	Y		Y		Y		
Cd	ICP-MS	µg/gm	36.4		36.9										
Ce	ICP-MS	µg/gm	27.2		27.0										
La	ICP-MS	µg/gm	23.4		23.1										
Nd	ICP-MS	µg/gm	48.7		48.1										
Pb	ICP-MS	µg/gm	112		111										
Sample No.			189040	02-1948	189041	02-1966		192875		192870		192871		192872	192874
Analysis	Method	Units													
Free OH-	Titration	molar	0.277		0.268			0.924		0.775		0.781		0.78	0.779
Total OH-	Titration	molar	1.69		1.62			2.51		1.93		1.92		2.00	1.95
Other Base	Titration	molar	0.463		0.477			0.493		0.508		0.528		0.509	0.471
Chloride (Cl^-)	IC-Anion	µg/gm	2940	2643	2760	2606									
Fluoride (Fl^-)	IC-Anion	µg/gm	668	454	568	402									
Formate ($HCOO^-$)	IC-Anion	µg/gm	NA	5618	NA	5530									
Nitrate (NO_3^-)	IC-Anion	µg/gm	10100	95819	93500	96970									
Nitrite (NO_2^-)	IC-Anion	µg/gm	42900	39332	41900	40303									
Oxalate ($C_2O_4^{2-}$)	IC-Anion	µg/gm		<388		289									
Phosphate (PO_4^{3-}	IC-Anion	µg/gm	3480	1391	2930	1576									
Sulfate (SO_4^{2-})	IC-Anion	µg/gm	7220	7642	6900	8106									
Sample No.										192867		192868		192869	192873
Analysis	Method	Units													
Total Carbon	TIC/TOC	µg/ml	22500		21800					16700		16600		16600	16900
TOC	TIC/TOC	µg/ml	13900		13820					9380		9280		9220	9310
TIC	TIC/TOC	µg/ml	8590		7980					7320		7320		7380	7590

BATCH 4A ANALYTICAL RESULTS													
Solids Analysis													
Sample Description			Solids from AN-102R2 slurry after caustic addition	Solids from AN-102R2 slurry after $Sr(NO_3)_2$ added	Solids from AN-102R2 slurry 30 min after reagents added	Solids from AN-102R2 slurry 1 hour after reagents added	Solids from AN-102R2 slurry 2 hours after reagents added	Solids from AN-102R2 slurry 3 hours after reagents added	Solids from AN-102R2 slurry 4 hours after reagents added	Solids from AN-102R2 slurry 4 hours after reagents added	Solids from AN-102R2 slurry 22 hours after reagents added	Solids from AN-102R2 slurry 22 hours after reagents added	Post Filtration Solids
EDL Sample No.			4A-4S	4A-5S	4A-5S	4A-7S	4A-8S	4A-9S	4A-10S		4A-11S		
Time after Reagent Add (hrs)			N/A	N/A	0.5	1	2	3	4	4	22	22	
Identity	Units	Method											
Quantity collected	grams												
Sample No.									03-0589 A	03-0589 B	03-0592 A	03-0592 B	194334
Al	ηg/gm	ICP-ES	S	S	S	S	S	S	3690	3670	3880	3720	9021
B	ηg/gm	ICP-ES	A	A	A	A	A	A	<100	<100	<100	<100	1018
Ba	ηg/gm	ICP-ES	M	M	M	M	M	M					2075
Ca	ηg/gm	ICP-ES	P	P	P	P	P	P	13700	13500	14100	13300	14056
Cd	ηg/gm	ICP-ES	L	L	L	L	L	L					153.4
Ce	ηg/gm	ICP-ES	E	E	E	E	E	E	1190	1150	1210	1170	
Co	ηg/gm	ICP-ES											
Cr	ηg/gm	ICP-ES	A	A	A	A	A	A	100	100	450	390	639.5
Cu	ηg/gm	ICP-ES	R	R	R	R	R	R	470	460	420	400	617.9
Fe	ηg/gm	ICP-ES	C	C	C	C	C	C	2370	2330	2610	2380	2797
K	ηg/gm	ICP-ES	H	H	H	H	H	H	630	610	600	580	517.4
La	ηg/gm	ICP-ES	I	I	I	I	I	I	1050	1020	1100	1040	
Mg	ηg/gm	ICP-ES	V	V	V	V	V	V					792.2
Mn	ηg/gm	ICP-ES	E	E	E	E	E	E	174000	173000	167000	163000	145582
Mo	ηg/gm	ICP-ES	D	D	D	D	D	D	<100	<100	<100	<100	
Na	ηg/gm	ICP-ES							48500	54000	49800	48600	70722
Nd	ηg/gm	ICP-ES	O	O	O	O	O	O	2190	2140	2300	2200	
Ni	ηg/gm	ICP-ES	N	N	N	N	N	N	1650	1670	1700	1640	11867
P	ηg/gm	ICP-ES	L	L	L	L	L	L	2300	2370	2340	2150	1987
Pb	ηg/gm	ICP-ES	Y	Y	Y	Y	Y	Y	4790	4730	4960	4860	4869
S	ηg/gm	ICP-ES							620	680	640	590	
Sr	ηg/gm	ICP-ES							266000	267000	246000	243000	288860
Si	ηg/gm	ICP-ES							380	340	390	390	4855
W	ηg/gm	ICP-ES											
Zn	ηg/gm	ICP-ES							<100	<100	<100	<100	370.0
Zr	ηg/gm	ICP-ES							300	220	250	230	479.8

SRT-ADS-03-0369

Sample ID

ADS No.	Customer ID
3-189067	RPP-WTP-PREC4A-1VOA

Discussion of Results

One sample was submitted, for volatile organic compound (VOC) and permanent gas analysis. The detection limit for permanent gases was 0.1%, and for VOC analysis was 0.1 ppmv for this study. Neither VOC analytes nor hydrogen were detected in sample RPP-WTP-PREC4A-1VOA. Results are tabulated below.

Analyte	Concentration
Oxygen	21 % +/- 10%
Nitrogen	78 % +/- 10%
Hydrogen	< 0.1 % +/- 10%
VOC Analytes	< 0.1 ppmv +/- 10%

Experimental - VOA

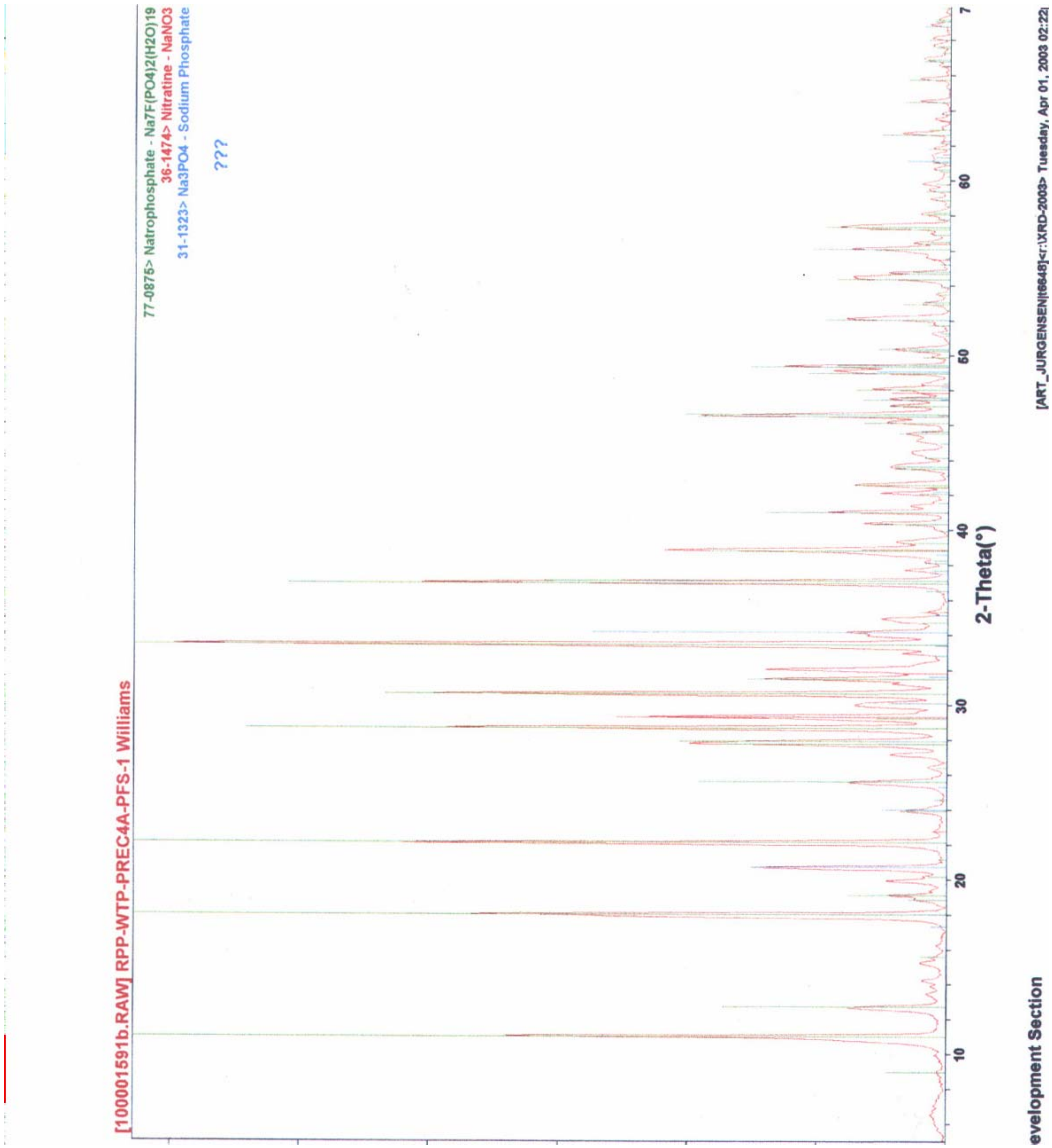
The sample was analyzed by purge and trap Gas Chromatography / Mass Spectrometry (GC/MS).
GC/MS analysis was employed to identify organic compounds in the samples. Analysis were carried out in building 773-A, laboratory B-159.
It should be noted that ADS is not certified by DHEC for NPDES discharge compliance monitoring.
Analytical separations were carried out on a Hewlett Packard 6890 gas chromatograph, equipped with a 20 m DB-624 column, with 0.18 mm diameter and 1.0 um film thickness. Quantitation was performed using a Hewlett Packard 5973 mass selective detector. The mass spectrometer tuning was confirmed within 24 hours prior to each measurement using perfluorotributylamine.

Experimental - permanent gas analysis

Permanent gas analysis were carried out on a Hewlett Packard model 5890 gas chromatograph (GC) equipped with a molecular sieve column and thermal conductivity detector (TCD). Calibration was carried out prior to and after the sample analyses using Scott Gas Mix 218, as well as calibration verification using blank air. Samples were run in duplicate for confirmation of results.

Experimental

Solid, liquid, and gas samples were analyzed using purge and trap Gas Chromatography / Mass Spectrometry (GC/MS).
GC/MS analysis was employed to identify organic compounds in the samples. Analyses were carried out in building 773-A, laboratory B-159. It should be noted that ADS is not certified by DHEC for NPDES discharge compliance monitoring.
Samples were concentrated using a Tekmar 2016 Purge and Trap concentrator, using a three stage (10 cm Carbopack B / 6 cm Carboxen 1000 / 1 cm Carboxen 1001) trap. Analytical separations were carried out on a Hewlett Packard 6890 gas chromatograph, equipped with a 20 m DB-624 column, with 0.18 mm diameter and 1.0 um film thickness.
Quantification was performed using a Hewlett Packard 5973 mass selective detector.
The mass spectrometer tuning was confirmed within 24 hours prior to each measurement using perfluorotributylamine.
Some VOC samples for this study were analyzed on the following instrument.
Volatile organic analyses were performed by Gas Chromatography - Mass Spectrometry (GC-MS), using the ADS method 2656 (Contract Laboratory Program SOW 7-93 for Volatile Organics).
Samples were concentrated using an OI Analytical model 4460A Dynamic Headspace concentrator (Purge and Trap), using a three stage (10 cm Carbopack B / 6 cm Carboxen 1000 / 1 cm Carboxen 1001) trap.
Separation was performed with a Hewlett Packard 5890 series II gas chromatograph on a 105m x 0.32 mm VOCOL glass capillary column with 3 um film thickness. Quantitation was performed with a Hewlett Packard model 5971 quadrupole mass spectrometer. Internal standard and recovery surrogate compounds were added as specified in the Contract Laboratory Program for volatile organics (SOW 7-93).
The mass spectrometer tuning was confirmed within 12 hours prior to each measurement using 4-bromofluorobenzene.
Tuning verification was performed against CLP tuning requirements, specifically to optimize CLP requirements for high mass sensitivity.
50/95 ratios which are between 8%-15%, may require appropriate flagging if used for other purposes.


[100001591b.RAW] RPP-WTP-PREC4A-PFS-1 Williams
77-0875> Natrophosphate - Na7F(PO4)2(H2O)19
36-1474> Nitratine - NaNO3
31-1323> Na3PO4 - Sodium Phosphate
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2-Theta(°)
evelopment Section
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APPENDIX I

PARTICLE-SIZE DATA

<u>Note on measurement uncertainties of the included data:</u>
No measurement uncertainties are listed because the measurement uncertainties for analytical data are beyond the scope and control of this task. There is reason to believe that all analytical data can be at least 15% accurate but no quantitative data are given to support this assertion.

Particle Size Distribution

Samples were taken before the precipitating reagents were added to each batch, at least 4 hours after they were added and others as directed by RPP such as after concentration of the slurry by the cross-flow filter. This section shows graphical representation of the microtrac particle size analysis with volumetric and numerical particle distribution results.

Slurry samples analyzed are:

Fig. I-
1. Batch 1 AN107 slurry 57 days after precipitation (VOLUME Distribution)
2. Batch 2 AN107 slurry 30 days after precipitation (VOLUME Distribution)
3. Batch 1 AN107 slurry 1 year after precipitation (NUMBER Distribution)
4. Batch 1 AN107 slurry 1 year after precipitation (NUMBER Distribution)
5. Batch 1 AN107 slurry 1 year after precipitation (NUMBER Distribution)
6. Batch 1 AN107 slurry 1 year after precipitation (NUMBER Distribution)
7. Batch 1 AN107 slurry 1 year after precipitation (VOLUME Distribution)
8. Batch 1 AN107 slurry 1 year after precipitation (VOLUME Distribution)
9. Batch 1 AN107 slurry 1 year after precipitation (VOLUME Distribution)
10. Batch 1 AN107 slurry 1 year after precipitation (VOLUME Distribution)
11. Batch 3C AN102R2 simulant before precipitation (NUMBER Distribution)
12. Batch 3C AN102R2 simulant before precipitation (VOLUME Distribution)
13. Batch 3C AN102R2 slurry four hours after precipitation (NUMBER Distribution)
14. Batch 3C AN102R2 slurry four hours after precipitation (VOLUME Distribution)
15. Batch 3C AN102R2 slurry after precipitation and dewatering to 8.4% Insoluble Solids by the Cross-flow Filter (NUMBER Distribution)
16. Batch 3C AN102R2 slurry after precipitation and dewatering to 8.4% Insoluble Solids by the Cross-flow Filter (VOLUME Distribution)
17. Batch 3B AN102R2 simulant before precipitation (NUMBER Distribution)
18. Batch 3B AN102R2 simulant before precipitation (VOLUME Distribution)
19. Batch 3B AN102R2 slurry four hours after precipitation (NUMBER Distribution)
20. Batch 3B AN102R2 slurry four hours after precipitation (NUMBER Distribution)
21. Batch 3B AN102R2 slurry four hours after precipitation (NUMBER Distribution)
22. Batch 3B AN102R2 slurry four hours after precipitation (NUMBER Distribution)
23. Batch 3B AN102R2 slurry four hours after precipitation (VOLUME Distribution)
24. Batch 3B AN102R2 slurry four hours after precipitation (VOLUME Distribution)
25. Batch 3B AN102R2 slurry four hours after precipitation (VOLUME Distribution)

26. Batch 3B AN102R2 slurry four hours after precipitation (VOLUME Distribution)
27. Batch 3A AN102R2 simulant before precipitation (NUMBER Distribution)
28. Batch 3A AN102R2 simulant before precipitation (NUMBER Distribution)
29. Batch 3A AN102R2 simulant before precipitation (NUMBER Distribution)
30. Batch 3A AN102R2 simulant before precipitation (NUMBER Distribution)
31. Batch 3A AN102R2 simulant before precipitation (VOLUME Distribution)
32. Batch 3A AN102R2 simulant before precipitation (VOLUME Distribution)
33. Batch 3A AN102R2 simulant before precipitation (VOLUME Distribution)
34. Batch 3A AN102R2 simulant before precipitation (VOLUME Distribution)
35. Batch 3A AN102R2 slurry four hours after precipitation (NUMBER Distribution)
36. Batch 3A AN102R2 slurry four hours after precipitation (NUMBER Distribution)
37. Batch 3A AN102R2 slurry four hours after precipitation (NUMBER Distribution)
38. Batch 3A AN102R2 slurry four hours after precipitation (NUMBER Distribution)
39. Batch 3A AN102R2 slurry four hours after precipitation (VOLUME Distribution)
40. Batch 3A AN102R2 slurry four hours after precipitation (NUMBER Distribution)
41. Batch 3A AN102R2 slurry four hours after precipitation (VOLUME Distribution)
42. Batch 3A AN102R2 slurry four hours after precipitation (VOLUME Distribution)
43. Batch 4A AN102R2 post filtration precipitation solids (VOLUME Distribution)
44. Batch 4A AN102R2 post filtration precipitation solids (NUMBER Distribution)
45. Batch 4A AN102R2 post filtration precipitation solids (VOLUME Distribution)
46. Batch 4A AN102R2 post filtration precipitation solids (NUMBER Distribution)

<u>Note on Particle Size Distribution Method</u>
Three of the methods available at the Savannah River Site to evaluate the particle size distribution utilize Microtrac equipment. They are:

Mono-laser diffraction analysis:
a. SRA150 standard range. 20 channels: 0.7 to 700 microns
b. SRA150 extended range, 40 channels:0.2 to 700 microns

Tri-laser diffraction analysis
a. X100 high resolution, 40 channels: 0.04 to 700 microns

Each method has limitations.

SRA150 standard range
No knowledge of particle transparency is needed and it gives immediate results. There is not enough resolution to discriminate between particle sizes and it is on the threshold of detection at the range of interest.

SRA150 extended range
This covers the particle size near the pore size of the cross-flow filter. Knowledge of particle transparency is needed for sub-micron particles, however the instrument will make an educated guess if not known.

X100 high resolution
This covers very small particles. The accuracy of the results is highly dependent on the knowledge of particle transparency and the index of refraction of the slurry. The measurement is very sensitive with more measurement uncertainty imparted to results determined without a detailed knowledge of slurry and solid optical properties.

The best method available when the sample was submitted was used. Previous measurements (21) indicate that for tests with one slurry sample using all three methods gave similar results. Specifically, particle size averages did not vary more than 15% and distribution characteristics remain the same.

Minimum size for SRA150 extended range
The stated range for this method, as given above, is 0.2 to 700 micron. However, as seen in the following Microtrac data sheets, it appears that the lower setting was set at 0.688 microns for an unknown reason. The 0.688 micron cutoff was sufficient to adequately portray the particle size distribution.

Note on Sample Preparation to perform a Microtrac Evaluation
Besides the methods to choose in evaluating samples, the sample must be prepared properly to obtain accurate results.

Diluent
The slurry sample is suspended in a large volume (>300ml) of diluent. The standard diluent is distilled water but due to the neutral pH and the solubility of solids in water, the Batch 3 and 4 slurry samples were suspended in the filtrate. Optically transparent filtrate free of solids was used. Batch 1 and 2 samples used a diluent solution of 1.5M $NaNO_3$ and 0.5M NaOH which was the same pH as the filtrate, optically transparent and was free of solids.

MICROTRAC - SRA150 Ver:7.01

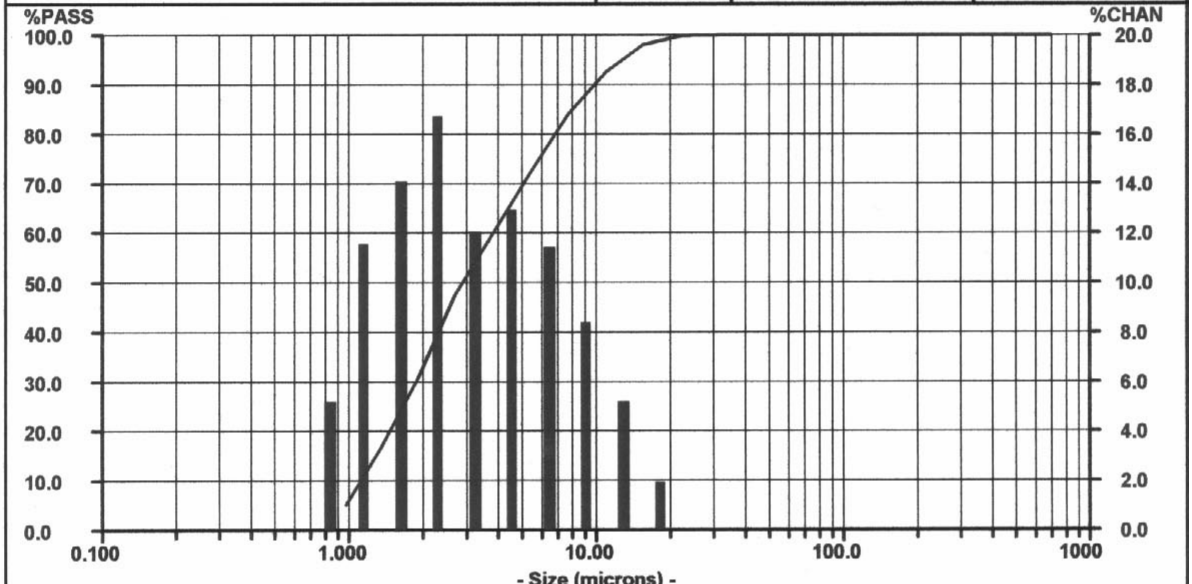
Particle Size

3-172181
10% FSS w/solids

Date: 11/16/01 Meas #: 5130
Time: 07:16 Pres #: 1

Willams, Michael

Summary	Percentiles		Dia	Vol%	Width
mv = 4.371	10% = 1.140	60% = 3.903	5.659	52%	6.956
mn = 1.225	20% = 1.495	70% = 5.094	1.656	48%	1.275
ma = 2.386	30% = 1.906	80% = 6.773			
cs = 2.515	40% = 2.336	90% = 9.691			
sd = 3.181	50% = 2.917	95% = 12.46			



SIZE	%PASS	%CHAN
704.0	100.00	0.00
497.8	100.00	0.00
352.0	100.00	0.00
248.9	100.00	0.00
176.0	100.00	0.00
124.5	100.00	0.00
88.00	100.00	0.00
62.23	100.00	0.00
44.00	100.00	0.00
31.11	100.00	0.09
22.00	99.91	1.91
15.56	98.00	5.27
11.00	92.73	8.46
7.778	84.27	11.42
5.500	72.85	12.98
3.889	59.87	12.15
2.750	47.72	16.80
1.945	30.92	14.11
1.375	16.81	11.52
0.972	5.29	5.29

Distribution: Volume
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 20
High Resolution: No
Filter On: N/A

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: N/A
Particle Transparency: N/A
Particle Refractive Index: N/A
Particle Shape: N/A

Database Path: C:\MTWIN\PDPSD.DB

Fluid: N/A
Fluid Refractive Index: N/A
Loading Factor: 0.0179
Transmission: 0.95
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-1. Batch 1 AN-107 slurry 57 days after precipitation
(VOLUME Distribution)

MICROTRAC - SRA150 Ver:7.01

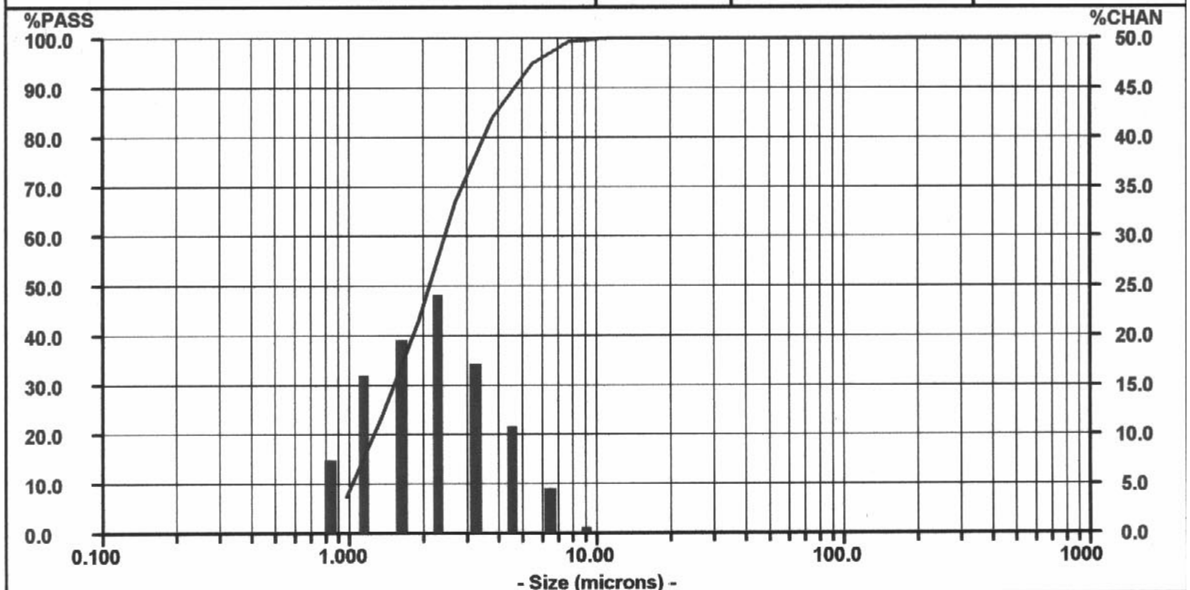
Particle Size

3-172182
10% FSS w/solids

Date: 11/16/01 Meas #: 5135
Time: 07:36 Pres #: 1

Willams, Michael

Summary	Percentiles		Dia	Vol%	Width
mv = 2.513	10% = 1.040	60% = 2.477	2.153	100%	2.689
mn = 1.205	20% = 1.288	70% = 2.893			
ma = 1.870	30% = 1.558	80% = 3.528			
cs = 3.208	40% = 1.855	90% = 4.575			
sd = 1.345	50% = 2.153	95% = 5.503			



SIZE	%PASS	%CHAN
704.0	100.00	0.00
497.8	100.00	0.00
352.0	100.00	0.00
248.9	100.00	0.00
176.0	100.00	0.00
124.5	100.00	0.00
88.00	100.00	0.00
62.23	100.00	0.00
44.00	100.00	0.00
31.11	100.00	0.00
22.00	100.00	0.00
15.56	100.00	0.00
11.00	100.00	0.51
7.778	99.49	4.50
5.500	94.99	10.87
3.889	84.12	17.09
2.750	67.03	24.07
1.945	42.96	19.52
1.375	23.44	16.01
0.972	7.43	7.43

Distribution: Volume
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 20
High Resolution: No
Filter On: N/A

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: N/A
Particle Transparency: N/A
Particle Refractive Index: N/A
Particle Shape: N/A

Database Path: C:\MTWIN\PDPSD.DB

Fluid: N/A
Fluid Refractive Index: N/A
Loading Factor: 0.0285
Transmission: 0.90
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-2. Batch 2 AN-107 slurry 30 days after precipitation
(VOLUME Distribution)

ver:7.01

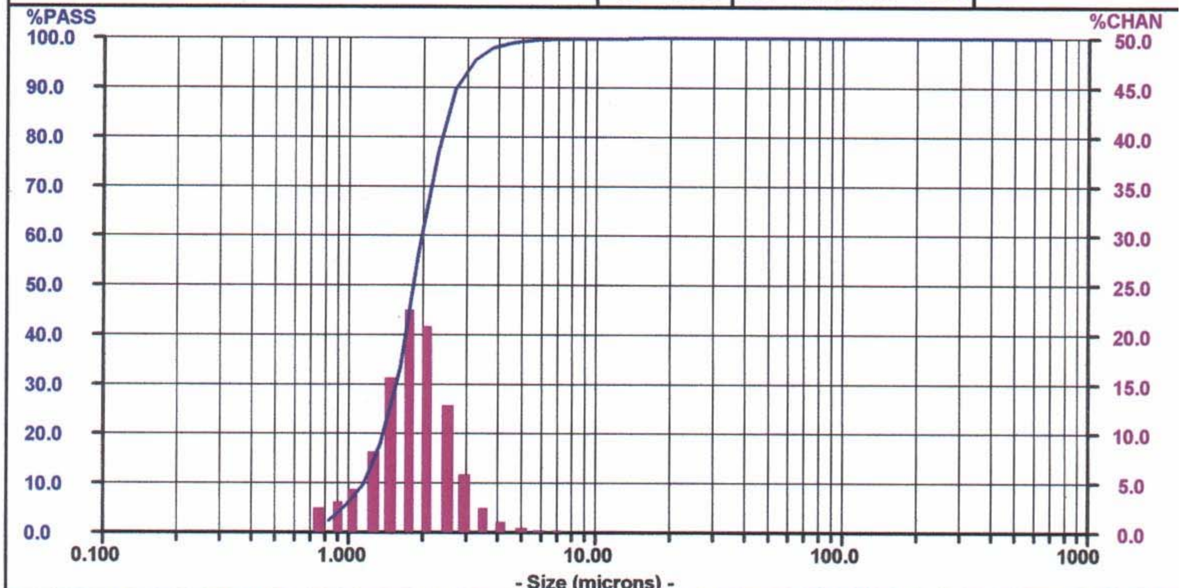
Particle Size

3-185989
rpp-wtp-prec1-1sl

Date: 10/29/02 Meas #: 6095
Time: 14:10 Pres #: 1

Williams, M.

Summary	Percentiles		Dia	Num%	Width
mv = 4.701	10% = 1.161	60% = 2.005	1.859	100%	1.182
mn = 1.971	20% = 1.414	70% = 2.173			
ma = 2.882	30% = 1.582	80% = 2.393			
cs = 2.082	40% = 1.724	90% = 2.769			
sd = 0.591	50% = 1.859	95% = 3.195			



SIZE	%PASS	%CHAN
704.0	100.00	0.00
592.0	100.00	0.00
497.8	100.00	0.00
418.6	100.00	0.00
352.0	100.00	0.00
296.0	100.00	0.00
248.9	100.00	0.00
209.3	100.00	0.00
176.0	100.00	0.00
148.0	100.00	0.00
124.5	100.00	0.00
104.7	100.00	0.00
88.00	100.00	0.00
74.00	100.00	0.00
62.23	100.00	0.00
52.33	100.00	0.00
44.00	100.00	0.00
37.00	100.00	0.00
31.11	100.00	0.00
26.16	100.00	0.00
22.00	100.00	0.00
18.50	100.00	0.00
15.56	100.00	0.01
13.08	99.99	0.01
11.00	99.98	0.03

SIZE	%PASS	%CHAN
9.250	99.95	0.06
7.778	99.89	0.13
6.541	99.76	0.25
5.500	99.51	0.49
4.625	99.02	1.04
3.889	97.98	2.41
3.270	95.57	5.87
2.750	89.70	12.82
2.312	76.88	20.82
1.945	56.06	22.47
1.635	33.59	15.61
1.375	17.98	8.14
1.156	9.84	4.32
0.972	5.52	3.08
0.818	2.44	2.44

SIZE	%PASS	%CHAN

SIZE	%PASS	%CHAN

Distribution: Number
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 40
High Resolution: Yes
Filter On: Off

RunTime: 45 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Reflect
Particle Refractive Index: N/A
Particle Shape: N/A

Database Path: C:\MTWIN\PDPSD.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0087
Transmission: 0.95
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-3. Batch 1 AN-107 slurry 1 year after precipitation
(NUMBER Distribution)

MICROTRAC - SRA150

Ver:7.01

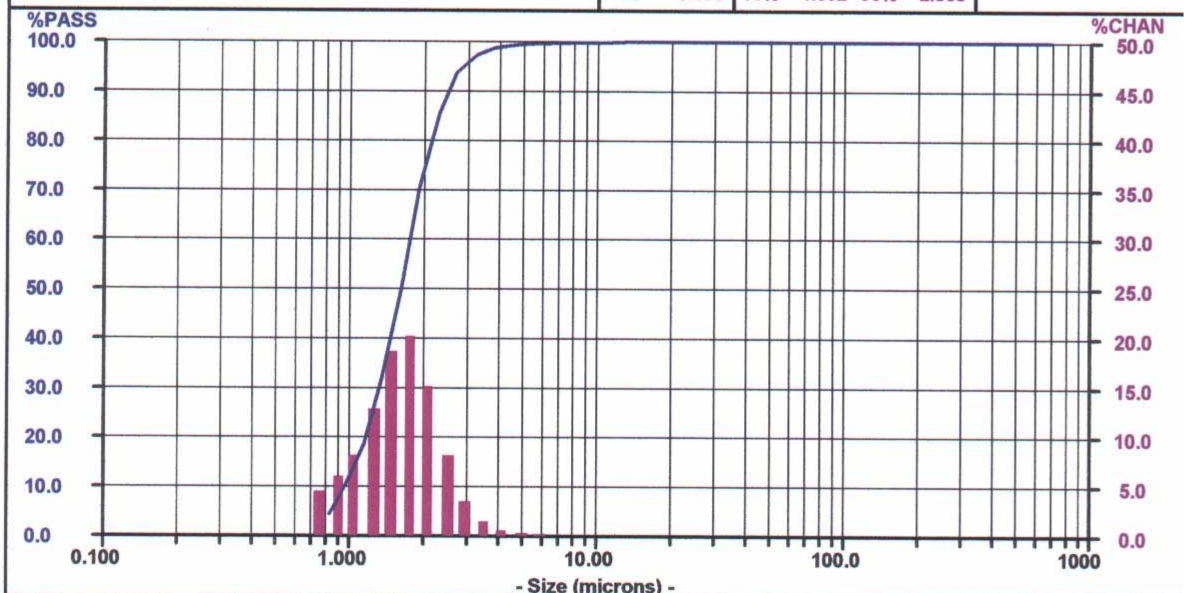
Particle Size

3-185989
rpp-wtp-prec1-1sl

Date: 10/29/02 Meas #: 6091
Time: 14:06 Pres #: 1

Williams, M.

Summary	Percentiles		Dia	Num%	Width
mv = 4.535	10% = 0.959	60% = 1.774	1.632	100%	1.161
mn = 1.733	20% = 1.180	70% = 1.937			
ma = 2.603	30% = 1.350	80% = 2.149			
cs = 2.305	40% = 1.494	90% = 2.498			
sd = 0.580	50% = 1.632	95% = 2.868			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.00	9.250	99.97	0.04						
592.0	100.00	0.00	7.778	99.93	0.07						
497.8	100.00	0.00	6.541	99.86	0.14						
418.6	100.00	0.00	5.500	99.72	0.29						
352.0	100.00	0.00	4.625	99.43	0.62						
296.0	100.00	0.00	3.889	98.81	1.43						
248.9	100.00	0.00	3.270	97.38	3.54						
209.3	100.00	0.00	2.750	93.84	8.18						
176.0	100.00	0.00	2.312	85.66	15.18						
148.0	100.00	0.00	1.945	70.48	20.23						
124.5	100.00	0.00	1.635	50.25	18.64						
104.7	100.00	0.00	1.375	31.61	12.91						
88.00	100.00	0.00	1.156	18.70	8.16						
74.00	100.00	0.00	0.972	10.54	6.02						
62.23	100.00	0.00	0.818	4.52	4.52						
52.33	100.00	0.00									
44.00	100.00	0.00									
37.00	100.00	0.00									
31.11	100.00	0.00									
26.16	100.00	0.00									
22.00	100.00	0.00									
18.50	100.00	0.00									
15.56	100.00	0.00									
13.08	100.00	0.01									
11.00	99.99	0.02									

Distribution: Number
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 40
High Resolution: Yes
Filter On: Off

RunTime: 45 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A

Database Path: C:\MTWIN\PDPSD.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0085
Transmission: 0.95
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-4. Batch 1 AN-107 slurry 1 year after precipitation
(NUMBER Distribution)

Ver:7.01

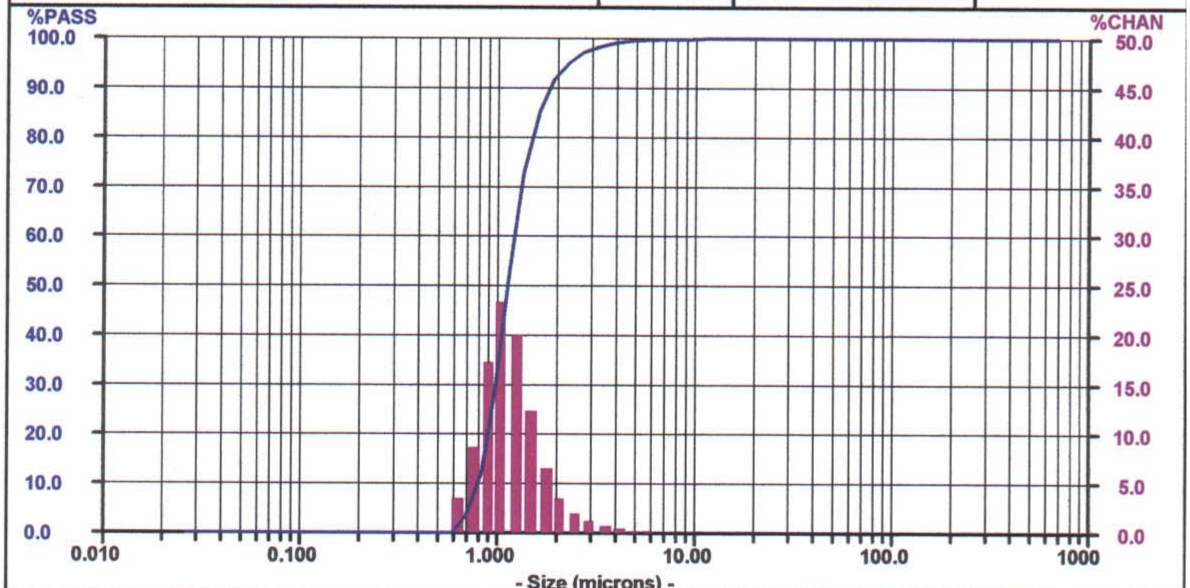
Particle Size Analysis

Williams, M.

3-185989
rpp-wtp-prec1-1sl

Date: 10/28/02 Meas #: 171
Time: 13:31 Pres #: 1

Summary	Percentiles		Dia	Num%	Width
mv = 4.179	10% = 0.791	60% = 1.223	1.132	100%	0.742
mn = 1.280	20% = 0.893	70% = 1.336			
ma = 2.293	30% = 0.976	80% = 1.498			
cs = 2.617	40% = 1.052	90% = 1.832			
sd = 0.371	50% = 1.132	95% = 2.274			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.00	9.250	99.99	0.03	0.122	0.00	0.00			
592.0	100.00	0.00	7.778	99.96	0.06	0.102	0.00	0.00			
497.8	100.00	0.00	6.541	99.90	0.13	0.086	0.00	0.00			
418.6	100.00	0.00	5.500	99.77	0.25	0.072	0.00	0.00			
352.0	100.00	0.00	4.625	99.52	0.42	0.061	0.00	0.00			
296.0	100.00	0.00	3.889	99.10	0.70	0.051	0.00	0.00			
248.9	100.00	0.00	3.270	98.40	1.16	0.043	0.00	0.00			
209.3	100.00	0.00	2.750	97.24	1.96	0.036	0.00	0.00			
176.0	100.00	0.00	2.312	95.28	3.46	0.030	0.00	0.00			
148.0	100.00	0.00	1.945	91.82	6.50	0.026	0.00	0.00			
124.5	100.00	0.00	1.635	85.32	12.35						
104.7	100.00	0.00	1.375	72.97	20.06						
88.00	100.00	0.00	1.156	52.91	23.37						
74.00	100.00	0.00	0.972	29.54	17.34						
62.23	100.00	0.00	0.818	12.20	8.71						
52.33	100.00	0.00	0.688	3.49	3.49						
44.00	100.00	0.00	0.578	0.00	0.00						
37.00	100.00	0.00	0.486	0.00	0.00						
31.11	100.00	0.00	0.409	0.00	0.00						
26.16	100.00	0.00	0.344	0.00	0.00						
22.00	100.00	0.00	0.289	0.00	0.00						
18.50	100.00	0.00	0.243	0.00	0.00						
15.56	100.00	0.00	0.204	0.00	0.00						
13.08	100.00	0.00	0.172	0.00	0.00						
11.00	100.00	0.01	0.145	0.00	0.00						

Distribution: Number
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 60
X100 Extended Range: Yes
Filter On: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Reflect
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN\MTWIN.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0165
Transmission: 0.95
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 40
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-5. Batch 1 AN-107 slurry 1 year after precipitation
(NUMBER Distribution)

ver:7.01

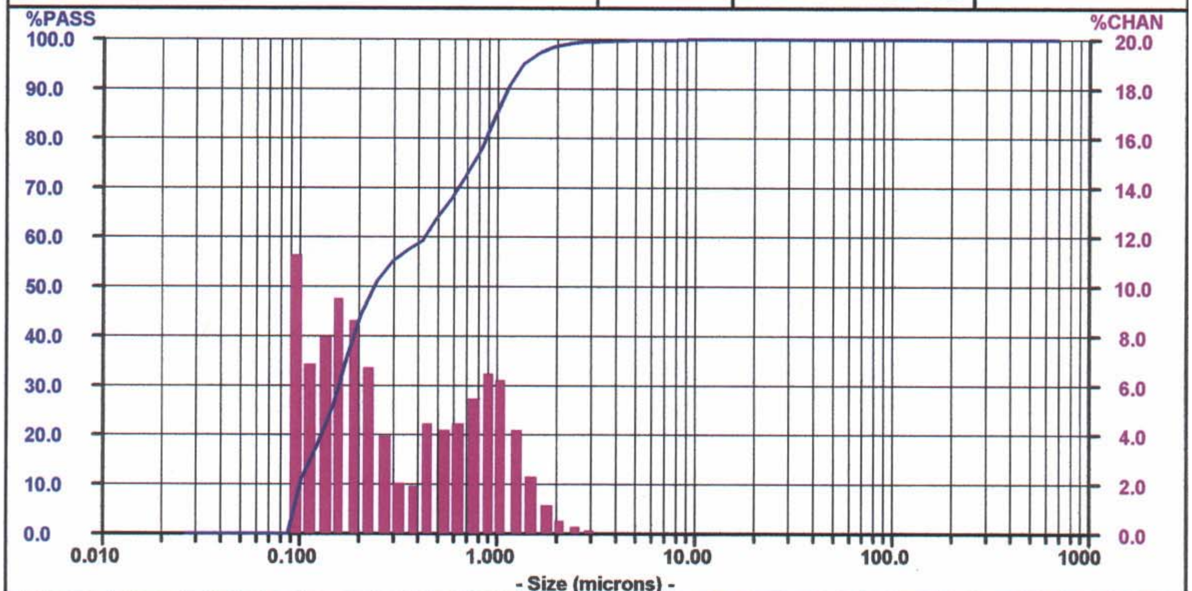
Particle Size Analysis

3-185989
rpp-wtp-prec1-1sl

Date: 10/28/02 Meas #: 167
Time: 13:28 Pres #: 1

Williams, M.

Summary	Percentiles		Dia	Num%	Width
mv = 4.208	10% = 0.100	60% = 0.422	0.907	36%	0.701
mn = 0.487	20% = 0.127	70% = 0.626	0.432	6%	0.087
ma = 1.889	30% = 0.155	80% = 0.863	0.168	46%	0.111
cs = 3.176	40% = 0.186	90% = 1.129	0.095	12%	0.010
sd = 0.422	50% = 0.235	95% = 1.369			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.00	9.250	100.00	0.01	0.122	18.22	6.88			
592.0	100.00	0.00	7.778	99.99	0.01	0.102	11.34	11.34			
497.8	100.00	0.00	6.541	99.98	0.02	0.086	0.00	0.00			
418.6	100.00	0.00	5.500	99.96	0.04	0.072	0.00	0.00			
352.0	100.00	0.00	4.625	99.92	0.07	0.061	0.00	0.00			
296.0	100.00	0.00	3.889	99.85	0.12	0.051	0.00	0.00			
248.9	100.00	0.00	3.270	99.73	0.20	0.043	0.00	0.00			
209.3	100.00	0.00	2.750	99.53	0.34	0.036	0.00	0.00			
176.0	100.00	0.00	2.312	99.19	0.60	0.030	0.00	0.00			
148.0	100.00	0.00	1.945	98.59	1.16	0.026	0.00	0.00			
124.5	100.00	0.00	1.635	97.43	2.34						
104.7	100.00	0.00	1.375	95.09	4.29						
88.00	100.00	0.00	1.156	90.80	6.21						
74.00	100.00	0.00	0.972	84.59	6.52						
62.23	100.00	0.00	0.818	78.07	5.51						
52.33	100.00	0.00	0.688	72.56	4.55						
44.00	100.00	0.00	0.578	68.01	4.24						
37.00	100.00	0.00	0.486	63.77	4.46						
31.11	100.00	0.00	0.409	59.31	1.96						
26.16	100.00	0.00	0.344	57.35	2.11						
22.00	100.00	0.00	0.289	55.24	4.05						
18.50	100.00	0.00	0.243	51.19	6.79						
15.56	100.00	0.00	0.204	44.40	8.64						
13.08	100.00	0.00	0.172	35.76	9.54						
11.00	100.00	0.00	0.145	26.22	8.00						

Distribution: Number
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 60
X100 Extended Range: Yes
Filter On: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0170
Transmission: 0.95
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 40
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Database Path: C:\MTWIN\MTWIN.DB

Figure I-6. Batch 1 AN-107 slurry 1 year after precipitation
(NUMBER Distribution)

MICROTRAC - SRA150 Ver:7.01

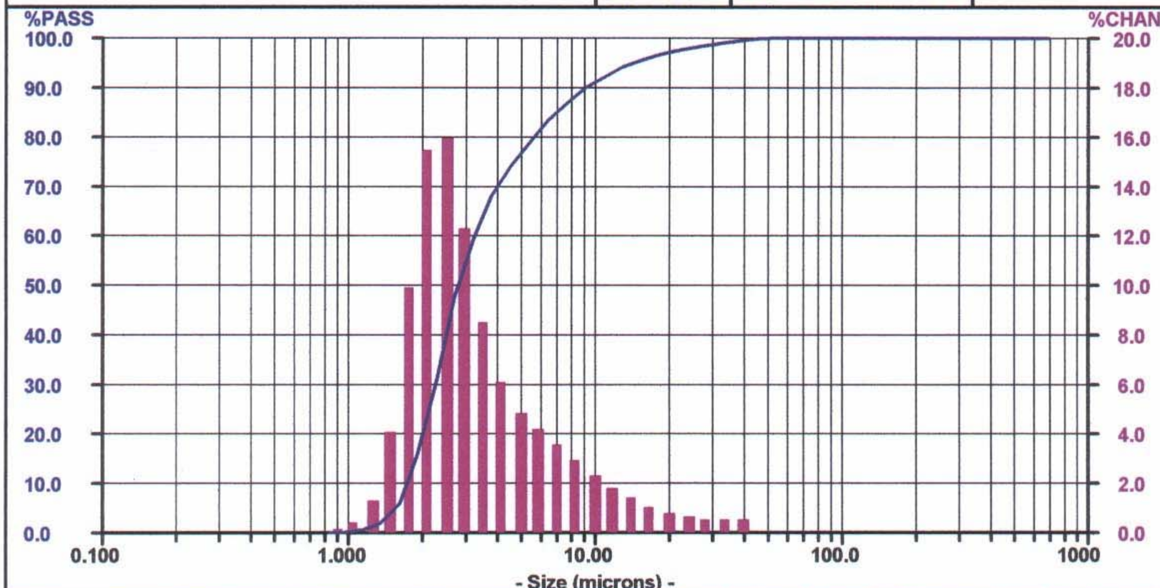
Particle Size

3-185989
rpp-wtp-prec1-1sl

Date: 10/29/02 Meas #: 6095
Time: 14:10 Pres #: 1

Williams, M.

Summary	Percentiles		Dia	Vol%	Width
mv = 4.701	10% = 1.777	60% = 3.290	2.843	100%	4.761
mn = 1.971	20% = 2.045	70% = 4.074			
ma = 2.882	30% = 2.280	80% = 5.663			
cs = 2.082	40% = 2.533	90% = 9.244			
sd = 2.380	50% = 2.843	95% = 14.24			



SIZE	%PASS	%CHAN
704.0	100.00	0.00
592.0	100.00	0.00
497.8	100.00	0.00
418.6	100.00	0.00
352.0	100.00	0.00
296.0	100.00	0.00
248.9	100.00	0.00
209.3	100.00	0.00
176.0	100.00	0.00
148.0	100.00	0.00
124.5	100.00	0.00
104.7	100.00	0.00
88.00	100.00	0.00
74.00	100.00	0.00
62.23	100.00	0.00
52.33	100.00	0.07
44.00	99.93	0.51
37.00	99.42	0.52
31.11	98.90	0.59
26.16	98.31	0.69
22.00	97.62	0.85
18.50	96.77	1.09
15.56	95.68	1.42
13.08	94.26	1.86
11.00	92.40	2.39
9.250	90.01	2.98
7.778	87.03	3.58
6.541	83.45	4.19
5.500	79.26	4.91
4.625	74.35	6.18
3.889	68.17	8.51
3.270	59.66	12.31
2.750	47.35	15.99
2.312	31.36	15.45
1.945	15.91	9.90
1.635	6.01	4.09
1.375	1.92	1.27
1.156	0.65	0.40
0.972	0.25	0.17
0.818	0.08	0.08

Distribution: Volume
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 40
High Resolution: Yes
Filter On: Off

RunTime: 45 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Reflect
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN\PDPSD.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0087
Transmission: 0.95
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

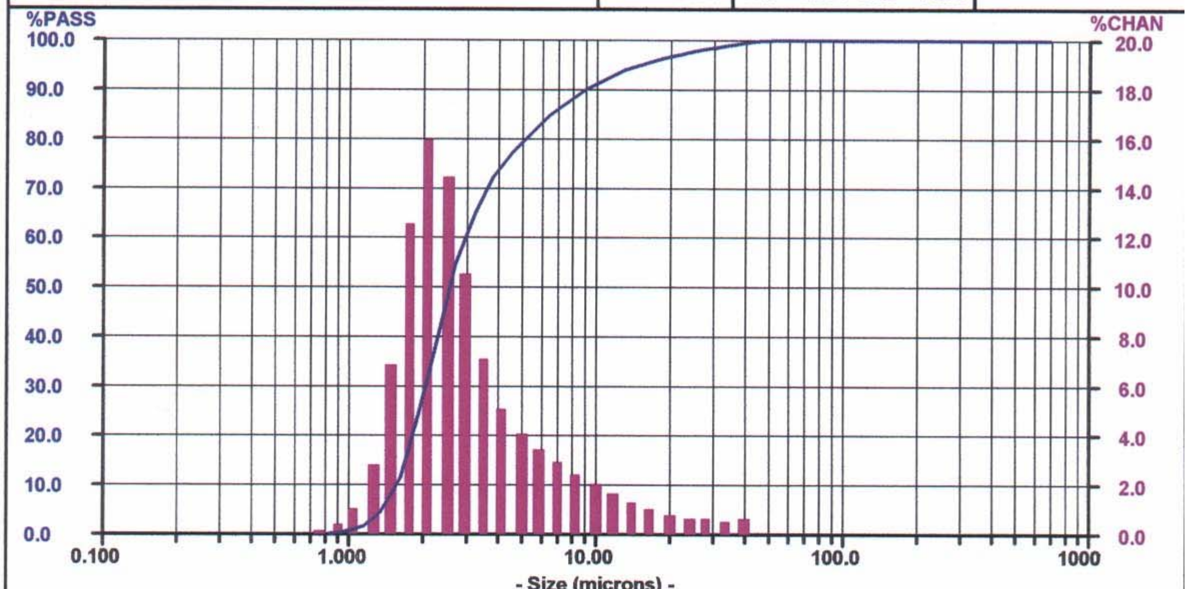
Figure I-7. Batch 1 AN-107 slurry 1 year after precipitation
(VOLUME Distribution)

ver:7.01

Particle Size	3-185989 rpp-wtp-prec1-1sl	Date: 10/29/02 Meas #: 6091 Time: 14:06 Pres #: 1

Williams, M.

Summary	Percentiles		Dia	Vol%	Width
mv = 4.535	10% = 1.588	60% = 2.986	2.594	100%	4.493
mn = 1.733	20% = 1.850	70% = 3.664			
ma = 2.603	30% = 2.076	80% = 5.158			
cs = 2.305	40% = 2.310	90% = 9.073			
sd = 2.246	50% = 2.594	95% = 14.93			



SIZE	%PASS	%CHAN
704.0	100.00	0.00
592.0	100.00	0.00
497.8	100.00	0.00
418.6	100.00	0.00
352.0	100.00	0.00
296.0	100.00	0.00
248.9	100.00	0.00
209.3	100.00	0.00
176.0	100.00	0.00
148.0	100.00	0.00
124.5	100.00	0.00
104.7	100.00	0.00
88.00	100.00	0.00
74.00	100.00	0.00
62.23	100.00	0.00
52.33	100.00	0.10
44.00	99.90	0.64
37.00	99.26	0.62
31.11	98.64	0.66
26.16	97.98	0.74
22.00	97.24	0.88
18.50	96.36	1.07
15.56	95.29	1.33
13.08	93.96	1.66
11.00	92.30	2.04
9.250	90.26	2.47
7.778	87.79	2.93
6.541	84.86	3.43
5.500	81.43	4.07
4.625	77.36	5.17
3.889	72.19	7.15
3.270	65.04	10.51
2.750	54.53	14.45
2.312	40.08	15.95
1.945	24.13	12.62
1.635	11.51	6.91
1.375	4.60	2.85
1.156	1.75	1.07
0.972	0.68	0.47
0.818	0.21	0.21

Distribution: Volume
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 40
High Resolution: Yes
Filter On: Off

RunTime: 45 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A

Database Path: C:\MTWIN\PDPSD.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0085
Transmission: 0.95
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-8. Batch 1 AN-107 slurry 1 year after precipitation
(VOLUME Distribution)

ver:7.01

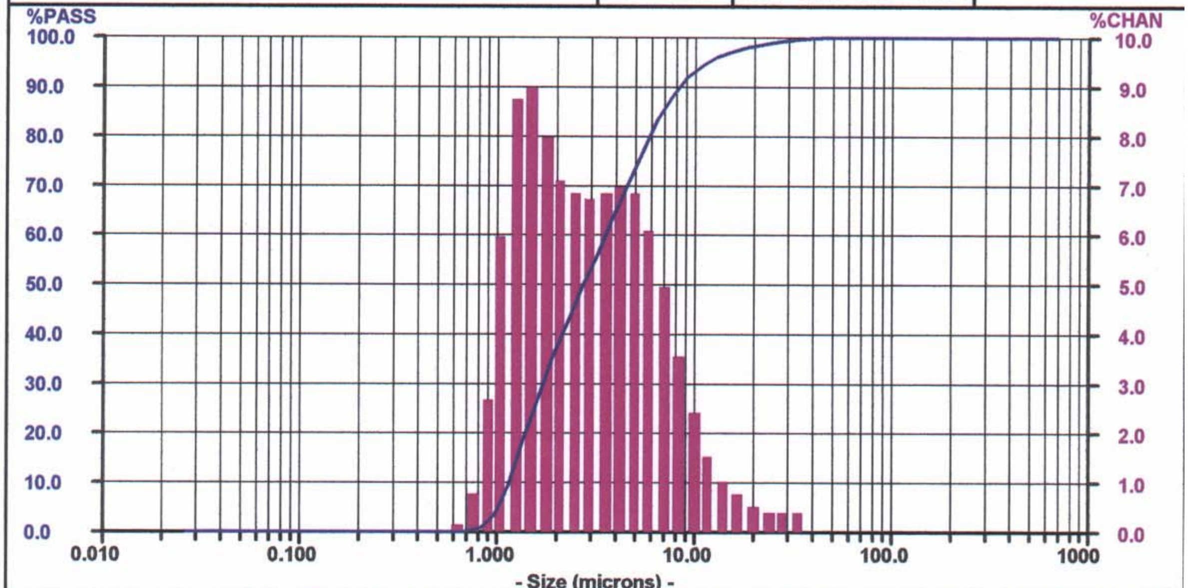
Particle Size Analysis

Williams, M.

3-185989
rpp-wtp-prec1-1sl

Date: 10/28/02 Meas #: 171
Time: 13:31 Pres #: 1

Summary	Percentiles		Dia	Vol%	Width
mv = 4.179	10% = 1.163	60% = 3.577	5.161	50%	5.829
mn = 1.280	20% = 1.415	70% = 4.579	1.550	50%	1.143
ma = 2.293	30% = 1.721	80% = 5.915			
cs = 2.617	40% = 2.161	90% = 8.327			
sd = 2.668	50% = 2.778	95% = 11.57			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.00	9.250	92.03	3.58	0.122	0.00	0.00			
592.0	100.00	0.00	7.778	88.45	4.96	0.102	0.00	0.00			
497.8	100.00	0.00	6.541	83.49	6.19	0.086	0.00	0.00			
418.6	100.00	0.00	5.500	77.30	6.89	0.072	0.00	0.00			
352.0	100.00	0.00	4.625	70.41	7.04	0.061	0.00	0.00			
296.0	100.00	0.00	3.889	63.37	6.94	0.051	0.00	0.00			
248.9	100.00	0.00	3.270	56.43	6.82	0.043	0.00	0.00			
209.3	100.00	0.00	2.750	49.61	6.85	0.036	0.00	0.00			
176.0	100.00	0.00	2.312	42.76	7.19	0.030	0.00	0.00			
148.0	100.00	0.00	1.945	35.57	8.02	0.026	0.00	0.00			
124.5	100.00	0.00	1.635	27.55	9.06						
104.7	100.00	0.00	1.375	18.49	8.76						
88.00	100.00	0.00	1.156	9.73	6.06						
74.00	100.00	0.00	0.972	3.67	2.68						
62.23	100.00	0.00	0.818	0.99	0.80						
52.33	100.00	0.00	0.688	0.19	0.19						
44.00	100.00	0.01	0.578	0.00	0.00						
37.00	99.99	0.39	0.486	0.00	0.00						
31.11	99.60	0.43	0.409	0.00	0.00						
26.16	99.17	0.50	0.344	0.00	0.00						
22.00	98.67	0.62	0.289	0.00	0.00						
18.50	98.05	0.82	0.243	0.00	0.00						
15.56	97.23	1.13	0.204	0.00	0.00						
13.08	96.10	1.64	0.172	0.00	0.00						
11.00	94.46	2.43	0.145	0.00	0.00						

Distribution: Volume
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 60
X100 Extended Range: Yes
Filter On: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Reflect
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN\MTWIN.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0165
Transmission: 0.95
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 40
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

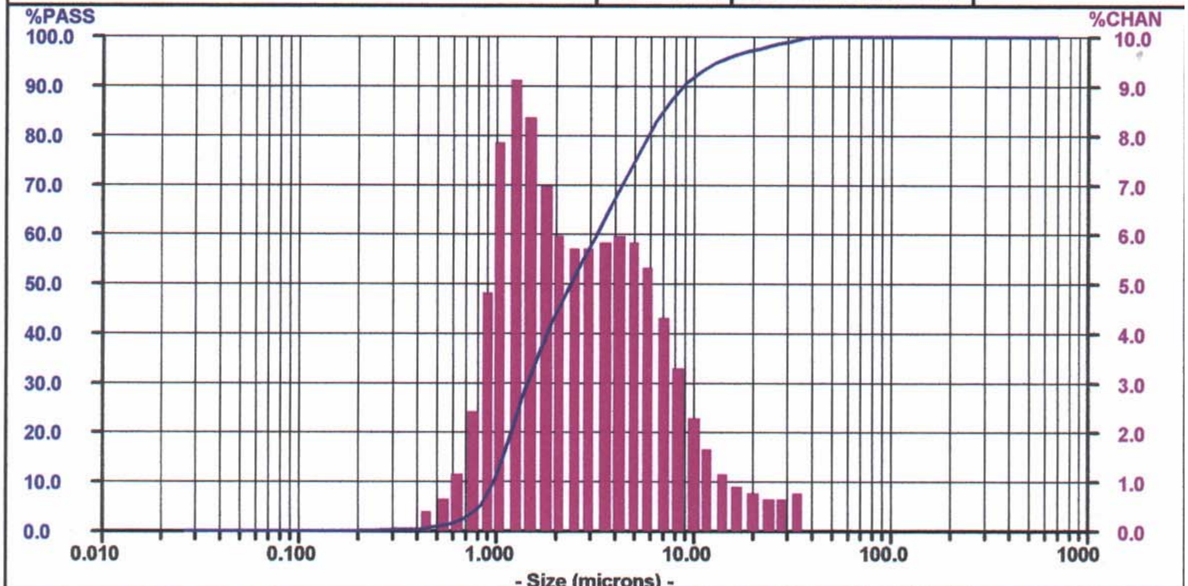
Figure I-9. Batch 1 AN-107 slurry 1 year after precipitation
(VOLUME Distribution)

ver:7.01

Particle Size Analysis	3-185989 rpp-wtp-prec1-1sl	Date: 10/28/02 Meas #: 167 Time: 13:28 Pres #: 1

Williams, M.

Summary	Percentiles		Dia	Vol%	Width
mv = 4.208	10% = 0.967	60% = 3.262	4.961	51%	6.896
mn = 0.487	20% = 1.201	70% = 4.377	1.302	49%	0.954
ma = 1.889	30% = 1.454	80% = 5.902			
cs = 3.176	40% = 1.821	90% = 8.822			
sd = 2.825	50% = 2.413	95% = 13.28			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.00	9.250	90.81	3.32	0.122	0.02	0.01			
592.0	100.00	0.00	7.778	87.49	4.40	0.102	0.01	0.01			
497.8	100.00	0.00	6.541	83.09	5.34	0.086	0.00	0.00			
418.6	100.00	0.00	5.500	77.75	5.85	0.072	0.00	0.00			
352.0	100.00	0.00	4.625	71.90	5.96	0.061	0.00	0.00			
296.0	100.00	0.00	3.889	65.94	5.86	0.051	0.00	0.00			
248.9	100.00	0.00	3.270	60.08	5.75	0.043	0.00	0.00			
209.3	100.00	0.00	2.750	54.33	5.75	0.036	0.00	0.00			
176.0	100.00	0.00	2.312	48.58	6.07	0.030	0.00	0.00			
148.0	100.00	0.00	1.945	42.51	6.97	0.026	0.00	0.00			
124.5	100.00	0.00	1.635	35.54	8.36						
104.7	100.00	0.00	1.375	27.18	9.15						
88.00	100.00	0.00	1.156	18.03	7.86						
74.00	100.00	0.00	0.972	10.17	4.92						
62.23	100.00	0.00	0.818	5.25	2.47						
52.33	100.00	0.00	0.688	2.78	1.21						
44.00	100.00	0.03	0.578	1.57	0.67						
37.00	99.97	0.76	0.486	0.90	0.42						
31.11	99.21	0.69	0.409	0.48	0.11						
26.16	98.52	0.70	0.344	0.37	0.07						
22.00	97.82	0.77	0.289	0.30	0.08						
18.50	97.05	0.94	0.243	0.22	0.08						
15.56	96.11	1.23	0.204	0.14	0.06						
13.08	94.88	1.69	0.172	0.08	0.04						
11.00	93.19	2.38	0.145	0.04	0.02						

Distribution: Volume
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 60
X100 Extended Range: Yes
Filter On: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN\MTWIN.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0170
Transmission: 0.95
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 40
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-10. Batch 1 AN-107 slurry 1 year after precipitation
(VOLUME Distribution)

MICROTRAC - SRA150 Ver:7.01

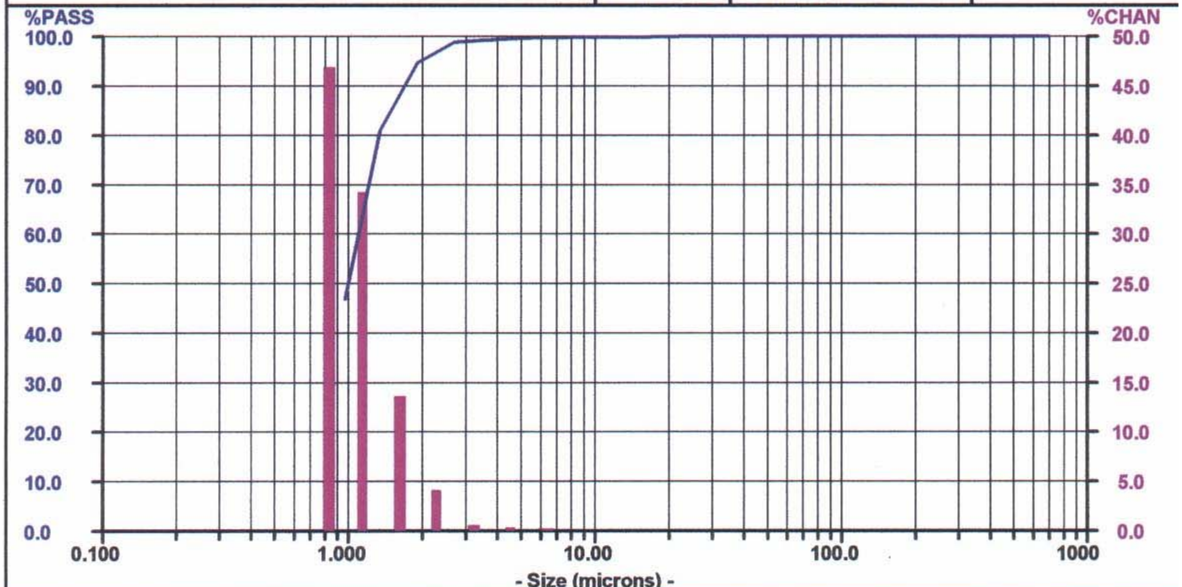
Particle Size

3-186610
rpp-wtp-prec3c-1sl

Date: 10/04/02 Meas #: 5814
Time: 09:31 Pres #: 1

Williams, Michael

Summary	Percentiles		Dia	Num%	Width
mv = 92.33	10% = 0.758	60% = 1.085	0.997	100%	0.650
mn = 1.154	20% = 0.815	70% = 1.197			
ma = 4.741	30% = 0.870	80% = 1.355			
cs = 1.266	40% = 0.928	90% = 1.644			
sd = 0.325	50% = 0.997	95% = 1.969			



SIZE	%PASS	%CHAN
704.0	100.00	0.00
497.8	100.00	0.00
352.0	100.00	0.00
248.9	100.00	0.00
176.0	100.00	0.00
124.5	100.00	0.00
88.00	100.00	0.00
62.23	100.00	0.00
44.00	100.00	0.00
31.11	100.00	0.00
22.00	100.00	0.01
15.56	99.99	0.02
11.00	99.97	0.05
7.778	99.92	0.14
5.500	99.78	0.32
3.889	99.46	0.57
2.750	98.89	4.14
1.945	94.75	13.67
1.375	81.08	34.20
0.972	46.88	46.88

SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN

Distribution: Number
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 20
High Resolution: No
Filter On: N/A

RunTime: 45 seconds
Run Number Avg of 3 runs
Particle: N/A
Particle Transparency: N/A
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN\PDPSD.DB

Fluid: N/A
Fluid Refractive Index: N/A
Loading Factor: 0.0185
Transmission: 0.96
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-11. Batch 3C AN102R2 simulant before precipitation
(NUMBER Distribution)

MICROTRAC - SRA150

Ver:7.01

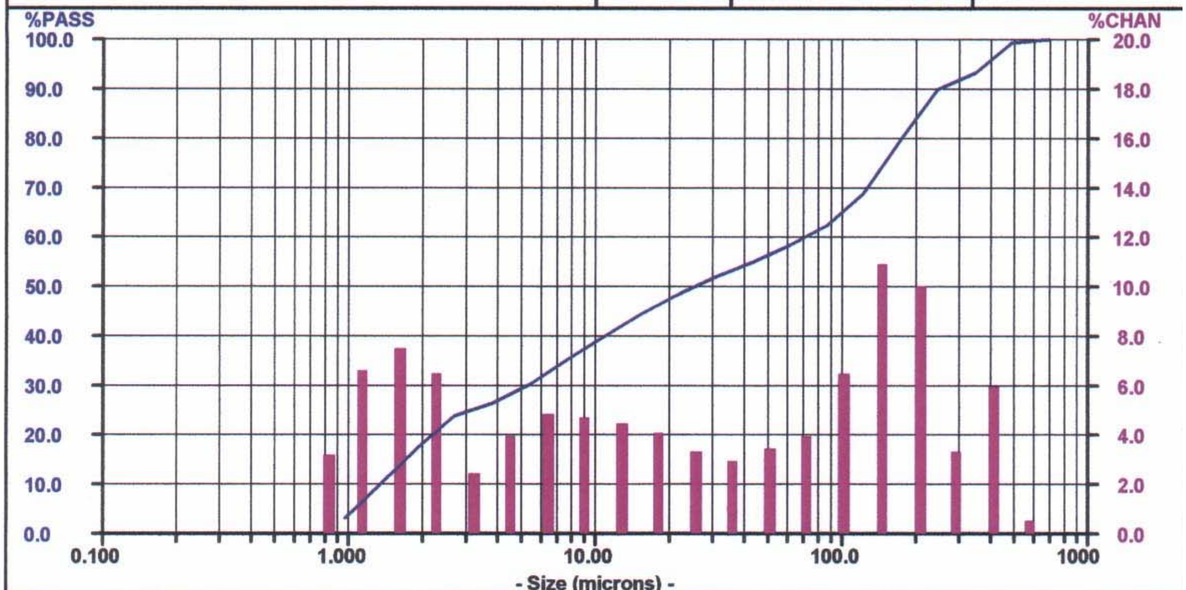
Particle Size

3-186610
rpp-wtp-prec3c-1sl

Date: 10/04/02 Meas #: 5814
Time: 09:31 Pres #: 1

Williams, Michael

Summary	Percentiles		Dia	Vol%	Width
mv = 92.33	10% = 1.381	60% = 72.19	387.3	10%	177.8
mn = 1.154	20% = 2.192	70% = 129.4	133.7	38%	138.2
ma = 4.741	30% = 5.315	80% = 176.3	9.395	28%	15.20
cs = 1.266	40% = 10.92	90% = 250.0	1.518	24%	1.184
sd = 98.59	50% = 25.22	95% = 387.9			



SIZE	%PASS	%CHAN
704.0	100.00	0.63
497.8	99.37	6.04
352.0	93.33	3.39
248.9	89.94	10.00
176.0	79.94	11.00
124.5	68.94	6.48
88.00	62.46	4.03
62.23	58.43	3.46
44.00	54.97	3.00
31.11	51.97	3.37
22.00	48.60	4.06
15.56	44.54	4.44
11.00	40.10	4.81
7.778	35.29	4.83
5.500	30.46	4.04
3.889	26.42	2.51
2.750	23.91	6.46
1.945	17.45	7.54
1.375	9.91	6.67
0.972	3.24	3.24

SIZE	%PASS	%CHAN

SIZE	%PASS	%CHAN

SIZE	%PASS	%CHAN

Distribution: Volume
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 20
High Resolution: No
Filter On: N/A

RunTime: 45 seconds
Run Number Avg of 3 runs
Particle: N/A
Particle Transparency: N/A
Particle Refractive Index: N/A
Particle Shape: N/A

Database Path: C:\MTWIN\PDPSD.DB

Fluid: N/A
Fluid Refractive Index: N/A
Loading Factor: 0.0185
Transmission: 0.96
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-12. Batch 3C AN102R2 simulant before precipitation
(VOLUME Distribution)

MICROTRAC - SRA150

Ver:7.01

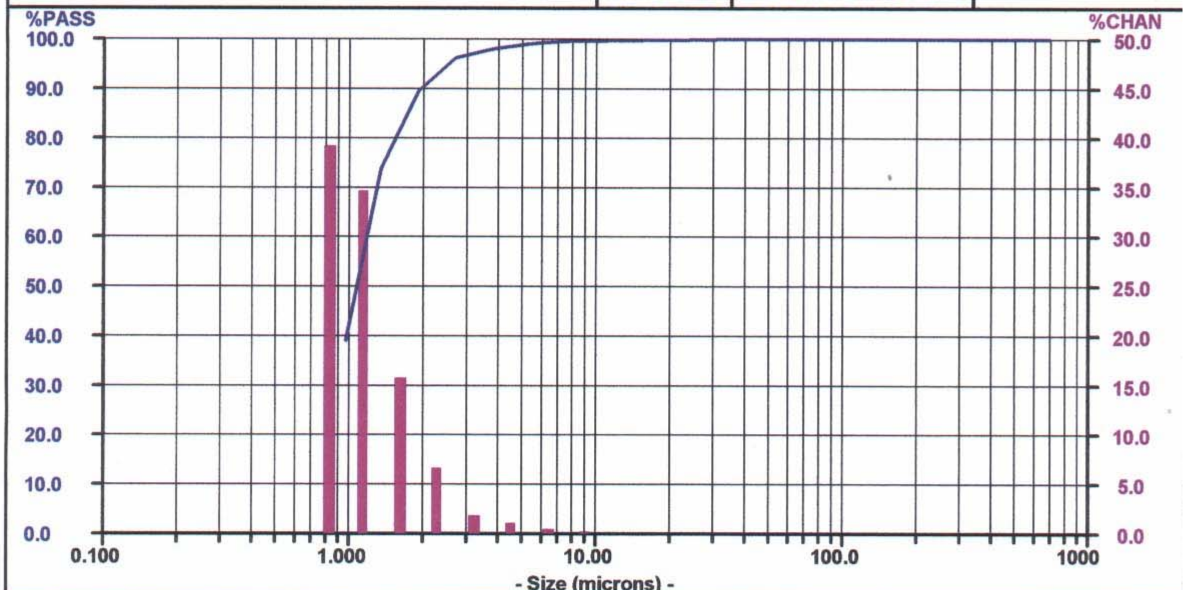
Particle Size

3-186611
rpp-wtp-prec3c-2sl

Date: 10/04/02 Meas #: 5818
Time: 10:28 Pres #: 1

Williams, Michael

Summary	Percentiles		Dia	Num%	Width
mv = 13.27	10% = 0.772	60% = 1.174	1.067	100%	0.841
mn = 1.326	20% = 0.839	70% = 1.310			
ma = 5.115	30% = 0.906	80% = 1.520			
cs = 1.173	40% = 0.978	90% = 1.976			
sd = 0.421	50% = 1.067	95% = 2.500			



SIZE	%PASS	%CHAN
704.0	100.00	0.00
497.8	100.00	0.00
352.0	100.00	0.00
248.9	100.00	0.00
176.0	100.00	0.00
124.5	100.00	0.00
88.00	100.00	0.00
62.23	100.00	0.00
44.00	100.00	0.00
31.11	100.00	0.01
22.00	99.99	0.03
15.56	99.96	0.09
11.00	99.87	0.24
7.778	99.63	0.50
5.500	99.13	1.04
3.889	98.09	1.87
2.750	96.22	6.65
1.945	89.57	15.71
1.375	73.86	34.62
0.972	39.24	39.24

Distribution: Number
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 20
High Resolution: No
Filter On: N/A

RunTime: 45 seconds
Run Number Avg of 3 runs
Particle: N/A
Particle Transparency: N/A
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN\PDPSD.DB

Fluid: N/A
Fluid Refractive Index: N/A
Loading Factor: 0.0159
Transmission: 0.93
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-13. Batch 3C AN102R2 slurry four hours after precipitation
(NUMBER Distribution)

MICROTRAC - SRA150 Ver:7.01

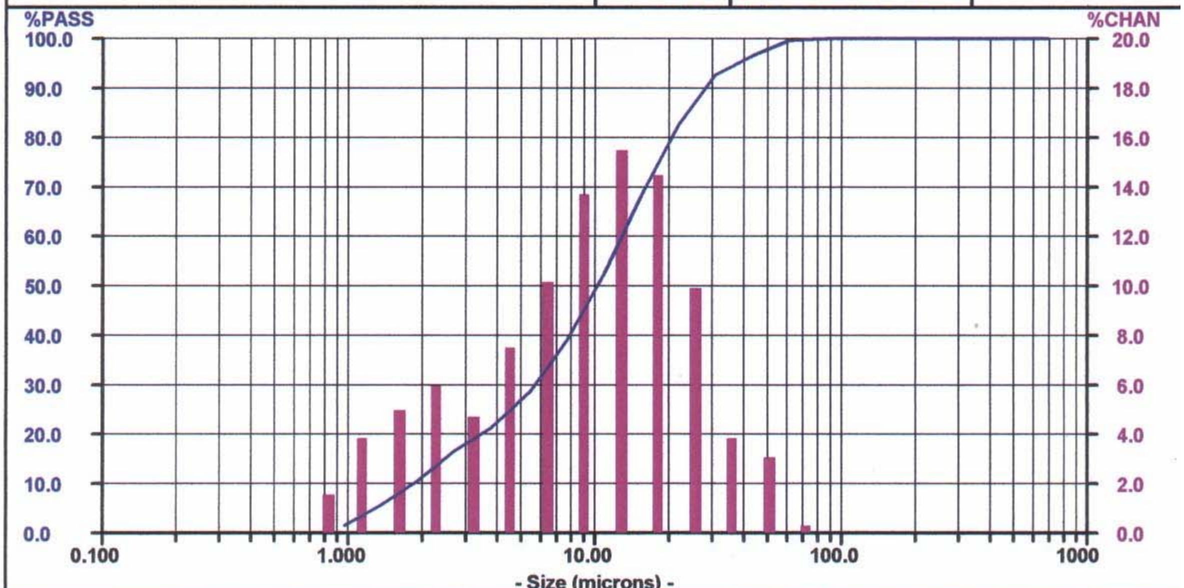
Particle Size

3-186611
rpp-wtp-prec3c-2sl

Date: 10/04/02 Meas #: 5818
Time: 10:28 Pres #: 1

Williams, Michael

Summary	Percentiles		Dia	Vol%	Width
mv = 13.27	10% = 1.885	60% = 12.97	12.47	83%	18.93
mn = 1.326	20% = 3.568	70% = 16.20	1.687	17%	1.258
ma = 5.115	30% = 5.765	80% = 20.50			
cs = 1.173	40% = 7.999	90% = 27.67			
sd = 10.07	50% = 10.32	95% = 36.87			



SIZE	%PASS	%CHAN
704.0	100.00	0.00
497.8	100.00	0.00
352.0	100.00	0.00
248.9	100.00	0.00
176.0	100.00	0.00
124.5	100.00	0.00
88.00	100.00	0.27
62.23	99.73	3.12
44.00	96.61	3.91
31.11	92.70	9.99
22.00	82.71	14.51
15.56	68.20	15.46
11.00	52.74	13.73
7.778	39.01	10.22
5.500	28.79	7.50
3.889	21.29	4.78
2.750	16.51	6.01
1.945	10.50	5.02
1.375	5.48	3.91
0.972	1.57	1.57

Distribution: Volume
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 20
High Resolution: No
Filter On: N/A

RunTime: 45 seconds
Run Number Avg of 3 runs
Particle: N/A
Particle Transparency: N/A
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN\PDPSD.DB

Fluid: N/A
Fluid Refractive Index: N/A
Loading Factor: 0.0159
Transmission: 0.93
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

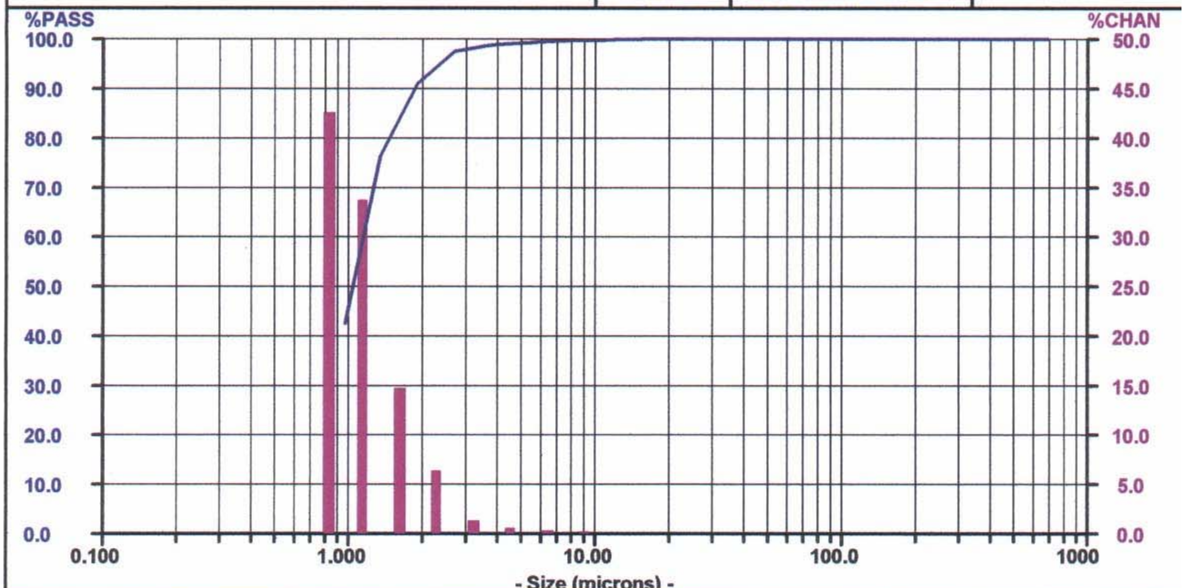
Figure I-14. Batch 3C AN102R2 slurry four hours after precipitation
(VOLUME Distribution)

MICROTRAC - SRA150 Ver:7.01

Particle Size	3-186895 rpp-wtp-prec3c-3sl	Date: 10/04/02 Meas #: 5826 Time: 11:07 Pres #: 1

Williams, Michael

Summary	Percentiles		Dia	Num%	Width
mv = 5.951	10% = 0.765	60% = 1.136	1.035	100%	0.777
mn = 1.248	20% = 0.827	70% = 1.266			
ma = 2.995	30% = 0.888	80% = 1.459			
cs = 2.003	40% = 0.954	90% = 1.869			
sd = 0.389	50% = 1.035	95% = 2.304			



SIZE	%PASS	%CHAN
704.0	100.00	0.00
497.8	100.00	0.00
352.0	100.00	0.00
248.9	100.00	0.00
176.0	100.00	0.00
124.5	100.00	0.00
88.00	100.00	0.00
62.23	100.00	0.00
44.00	100.00	0.00
31.11	100.00	0.00
22.00	100.00	0.00
15.56	100.00	0.03
11.00	99.97	0.13
7.778	99.84	0.36
5.500	99.48	0.61
3.889	98.87	1.37
2.750	97.50	6.41
1.945	91.09	14.69
1.375	76.40	33.78
0.972	42.62	42.62

SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN

Distribution: Number
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 20
High Resolution: No
Filter On: N/A

RunTime: 45 seconds
Run Number Avg of 3 runs
Particle: N/A
Particle Transparency: N/A
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN\PDPSD.DB

Fluid: N/A
Fluid Refractive Index: N/A
Loading Factor: 0.0509
Transmission: 0.89
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-15. Batch 3C AN102R2 slurry after precipitation and dewatering to 8.4 wt% Insoluble Solids by the Cross-flow Filter (NUMBER Distribution)

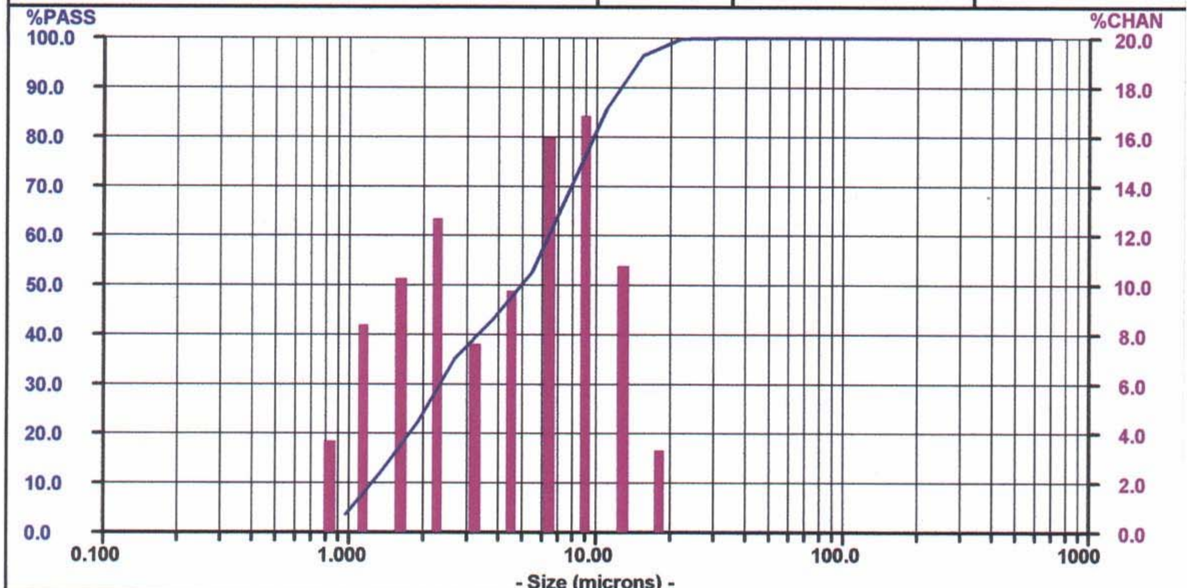
Particle Size

3-186895
rpp-wtp-prec3c-3sl

Date: 10/04/02 Meas #: 5826
Time: 11:07 Pres #: 1

Williams, Michael

Summary	Percentiles		Dia	Vol%	Width
mv = 5.951	10% = 1.271	60% = 6.510	7.605	65%	7.831
mn = 1.248	20% = 1.801	70% = 7.967	1.676	35%	1.269
ma = 2.995	30% = 2.366	80% = 9.712			
cs = 2.003	40% = 3.368	90% = 12.30			
sd = 4.500	50% = 5.073	95% = 14.51			



SIZE	%PASS	%CHAN
704.0	100.00	0.00
497.8	100.00	0.00
352.0	100.00	0.00
248.9	100.00	0.00
176.0	100.00	0.00
124.5	100.00	0.00
88.00	100.00	0.00
62.23	100.00	0.00
44.00	100.00	0.00
31.11	100.00	0.12
22.00	99.88	3.30
15.56	96.58	10.88
11.00	85.70	16.91
7.778	68.79	16.02
5.500	52.77	9.79
3.889	42.98	7.70
2.750	35.28	12.76
1.945	22.52	10.35
1.375	12.17	8.41
0.972	3.76	3.76

Distribution: Volume
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 20
High Resolution: No
Filter On: N/A

RunTime: 45 seconds
Run Number Avg of 3 runs
Particle: N/A
Particle Transparency: N/A
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN\PDPSD.DB

Fluid: N/A
Fluid Refractive Index: N/A
Loading Factor: 0.0509
Transmission: 0.89
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-16. Batch 3C AN102R2 slurry after precipitation and dewatering to8.4 wt% Insoluble Solids by the Cross-flow Filter (VOLUME Distribution)

MICROTRAC - SRA150 Ver:7.01

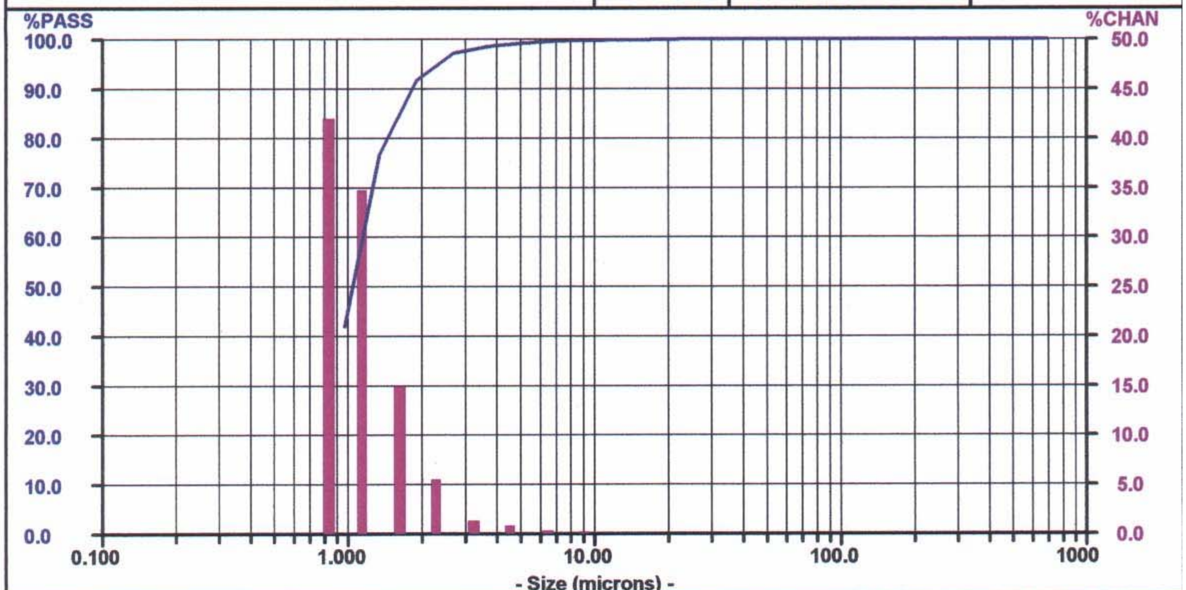
Particle Size

3-186612
rpp-wtp-prec3b-1sl

Date: 10/04/02 Meas #: 5822
Time: 10:47 Pres #: 1

Williams, Michael

Summary	Percentiles		Dia	Num%	Width
mv = 72.87	10% = 0.766	60% = 1.139	1.040	100%	0.753
mn = 1.254	20% = 0.830	70% = 1.264			
ma = 5.712	30% = 0.892	80% = 1.447			
cs = 1.050	40% = 0.958	90% = 1.825			
sd = 0.377	50% = 1.040	95% = 2.268			



SIZE	%PASS	%CHAN
704.0	100.00	0.00
497.8	100.00	0.00
352.0	100.00	0.00
248.9	100.00	0.00
176.0	100.00	0.00
124.5	100.00	0.00
88.00	100.00	0.00
62.23	100.00	0.00
44.00	100.00	0.00
31.11	100.00	0.00
22.00	100.00	0.02
15.56	99.98	0.05
11.00	99.93	0.14
7.778	99.79	0.34
5.500	99.45	0.80
3.889	98.65	1.33
2.750	97.32	5.54
1.945	91.78	15.02
1.375	76.76	34.77
0.972	41.99	41.99

Distribution: Number
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 20
High Resolution: No
Filter On: N/A

RunTime: 45 seconds
Run Number Avg of 3 runs
Particle: N/A
Particle Transparency: N/A
Particle Refractive Index: N/A
Particle Shape: N/A

Database Path: C:\MTWIN\PDPSD.DB

Fluid: N/A
Fluid Refractive Index: N/A
Loading Factor: 0.0258
Transmission: 0.96
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-17. Batch 3B AN102R2 simulant before precipitation
(NUMBER Distribution)

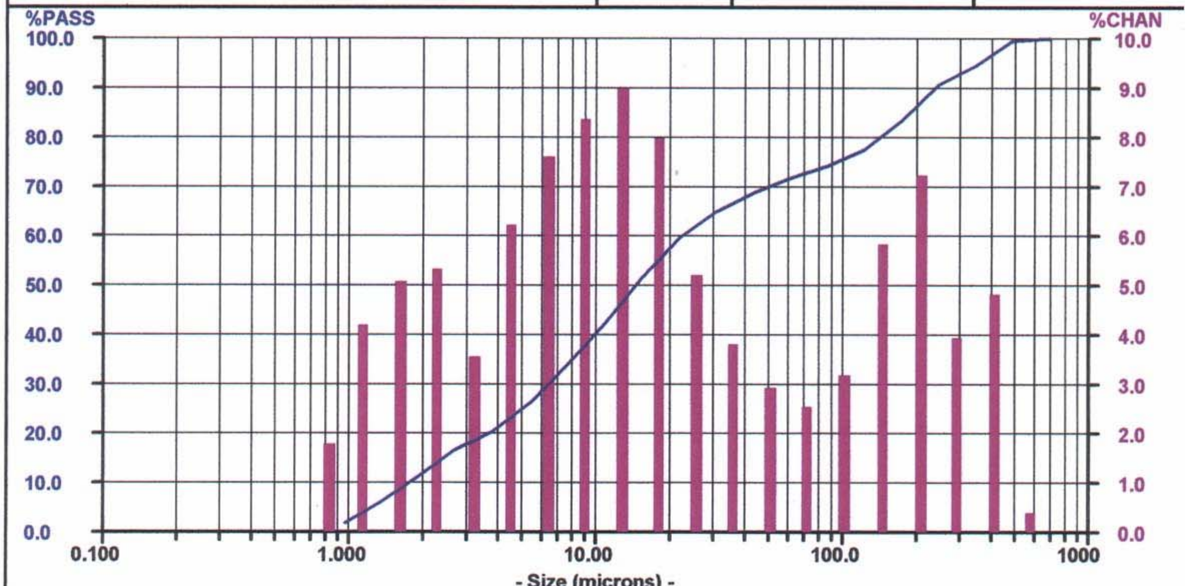
Particle Size

3-186612
rpp-wtp-prec3b-1sl

Date: 10/04/02 Meas #: 5822
Time: 10:47 Pres #: 1

Williams, Michael

Summary	Percentiles		Dia	Vol%	Width
mv = 72.87	10% = 1.799	60% = 22.45	368.8	9%	174.5
mn = 1.254	20% = 3.807	70% = 50.52	157.2	19%	120.1
ma = 5.712	30% = 6.493	80% = 146.7	11.72	55%	21.53
cs = 1.050	40% = 9.960	90% = 239.0	1.614	17%	1.233
sd = 89.10	50% = 14.63	95% = 359.8			



SIZE	%PASS	%CHAN
704.0	100.00	0.46
497.8	99.54	4.86
352.0	94.68	3.95
248.9	90.73	7.31
176.0	83.42	5.91
124.5	77.51	3.22
88.00	74.29	2.59
62.23	71.70	2.95
44.00	68.75	3.81
31.11	64.94	5.31
22.00	59.63	8.02
15.56	51.61	9.10
11.00	42.51	8.42
7.778	34.09	7.60
5.500	26.49	6.23
3.889	20.26	3.66
2.750	16.60	5.39
1.945	11.21	5.17
1.375	6.04	4.23
0.972	1.81	1.81

Distribution: Volume
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 20
High Resolution: No
Filter On: N/A

RunTime: 45 seconds
Run Number Avg of 3 runs
Particle: N/A
Particle Transparency: N/A
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN\PDPSD.DB

Fluid: N/A
Fluid Refractive Index: N/A
Loading Factor: 0.0258
Transmission: 0.96
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-18. Batch 3B AN102R2 simulant before precipitation
(VOLUME Distribution)

MICROTRAC - X100

Ver:7.01

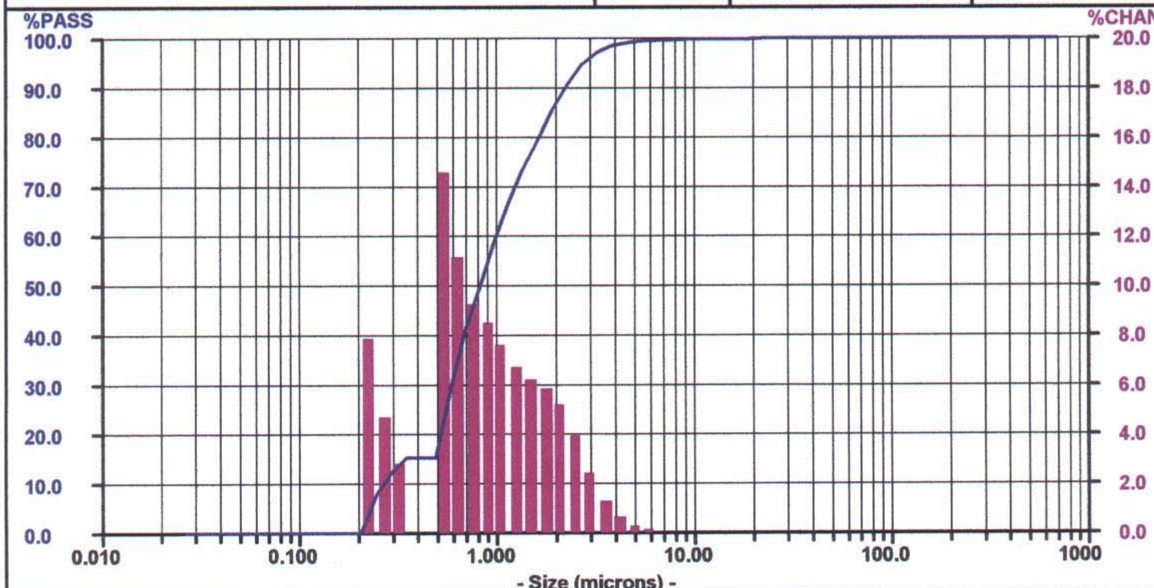
Particle Size Analysis

3-187613
rpp-wtp-prec3b-2sl

Date: 10/28/02 Meas #: 163
Time: 13:07 Pres #: 1

Williams, M.

Summary	Percentiles		Dia	Num%	Width
mv = 9.561	10% = 0.259	60% = 0.992	0.944	85%	1.428
mn = 1.115	20% = 0.519	70% = 1.256	0.242	15%	0.076
ma = 3.987	30% = 0.578	80% = 1.650			
cs = 1.505	40% = 0.673	90% = 2.244			
sd = 0.681	50% = 0.809	95% = 2.782			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.00	9.250	99.89	0.07	0.122	0.00	0.00			
592.0	100.00	0.00	7.778	99.82	0.12	0.102	0.00	0.00			
497.8	100.00	0.00	6.541	99.70	0.20	0.086	0.00	0.00			
418.6	100.00	0.00	5.500	99.50	0.35	0.072	0.00	0.00			
352.0	100.00	0.00	4.625	99.15	0.65	0.061	0.00	0.00			
296.0	100.00	0.00	3.889	98.50	1.27	0.051	0.00	0.00			
248.9	100.00	0.00	3.270	97.23	2.42	0.043	0.00	0.00			
209.3	100.00	0.00	2.750	94.81	3.96	0.036	0.00	0.00			
176.0	100.00	0.00	2.312	90.85	5.26	0.030	0.00	0.00			
148.0	100.00	0.00	1.945	85.59	5.89	0.026	0.00	0.00			
124.5	100.00	0.00	1.635	79.70	6.23						
104.7	100.00	0.00	1.375	73.47	6.76						
88.00	100.00	0.00	1.156	66.71	7.63						
74.00	100.00	0.00	0.972	59.08	8.50						
62.23	100.00	0.00	0.818	50.58	9.33						
52.33	100.00	0.00	0.688	41.25	11.19						
44.00	100.00	0.00	0.578	30.06	14.68						
37.00	100.00	0.00	0.486	15.38	0.00						
31.11	100.00	0.00	0.409	15.38	0.00						
26.16	100.00	0.00	0.344	15.38	2.80						
22.00	100.00	0.01	0.289	12.58	4.70						
18.50	99.99	0.01	0.243	7.88	7.88						
15.56	99.98	0.02	0.204	0.00	0.00						
13.08	99.96	0.03	0.172	0.00	0.00						
11.00	99.93	0.04	0.145	0.00	0.00						

Distribution: Number
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 60
X100 Extended Range: Yes
Filter On: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A

Database Path: C:\MTWIN\MTWIN.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0163
Transmission: 0.96
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 40
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

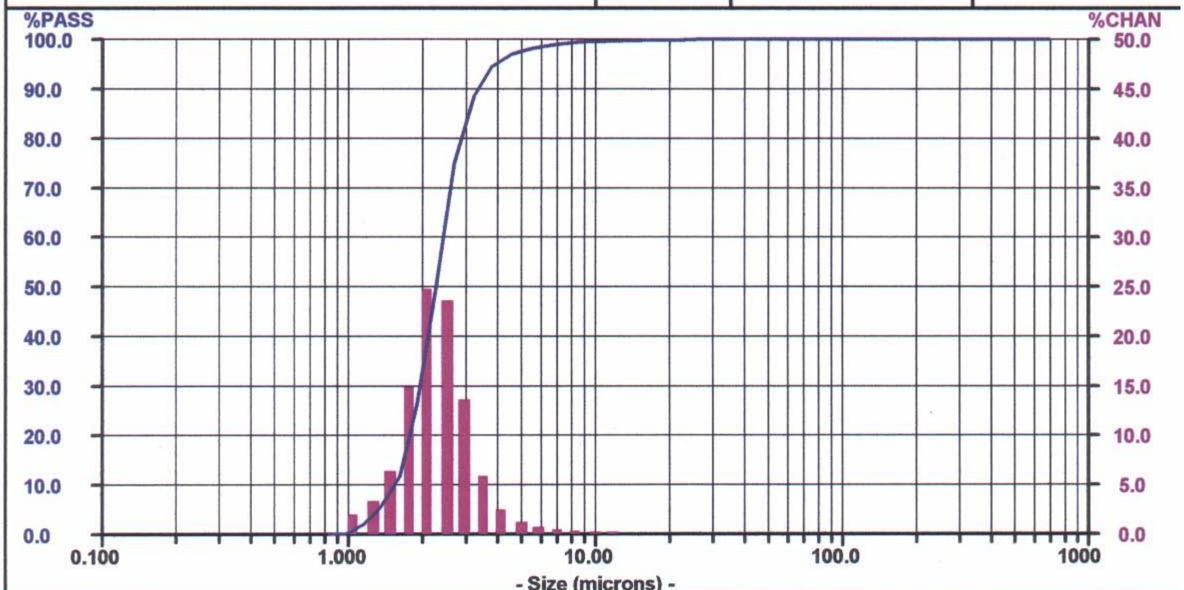
Figure I-19. Batch 3B AN102R2 slurry four hours after precipitation
(NUMBER Distribution)

MICROTRAC - SRA150 Ver:7.01

Particle Size	3-186613 rpp-wtp-prec3b-2sl	Date: 10/29/02 Meas #: 6087 Time: 13:45 Pres #: 1

Williams, M.

Summary	Percentiles		Dia	Num%	Width
mv = 8.952	10% = 1.578	60% = 2.452	2.290	100%	1.300
mn = 2.492	20% = 1.823	70% = 2.636			
ma = 4.532	30% = 1.996	80% = 2.892			
cs = 1.324	40% = 2.144	90% = 3.365			
sd = 0.650	50% = 2.290	95% = 3.980			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.00	9.250	99.53	0.28						
592.0	100.00	0.00	7.778	99.25	0.41						
497.8	100.00	0.00	6.541	98.84	0.66						
418.6	100.00	0.00	5.500	98.18	1.17						
352.0	100.00	0.00	4.625	97.01	2.46						
296.0	100.00	0.00	3.889	94.55	5.89						
248.9	100.00	0.00	3.270	88.66	13.60						
209.3	100.00	0.00	2.750	75.06	23.63						
176.0	100.00	0.00	2.312	51.43	24.73						
148.0	100.00	0.00	1.945	26.70	14.91						
124.5	100.00	0.00	1.635	11.79	6.43						
104.7	100.00	0.00	1.375	5.36	3.37						
88.00	100.00	0.00	1.156	1.99	1.99						
74.00	100.00	0.00	0.972	0.00	0.00						
62.23	100.00	0.00	0.818	0.00	0.00						
52.33	100.00	0.00									
44.00	100.00	0.00									
37.00	100.00	0.00									
31.11	100.00	0.00									
26.16	100.00	0.01									
22.00	99.99	0.02									
18.50	99.97	0.04									
15.56	99.93	0.08									
13.08	99.85	0.13									
11.00	99.72	0.19									

Distribution: Number
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 40
High Resolution: Yes
Filter On: Off

RunTime: 45 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN\PDPSD.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0130
Transmission: 0.96
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-20. Batch 3B AN102R2 slurry four hours after precipitation
(NUMBER Distribution)

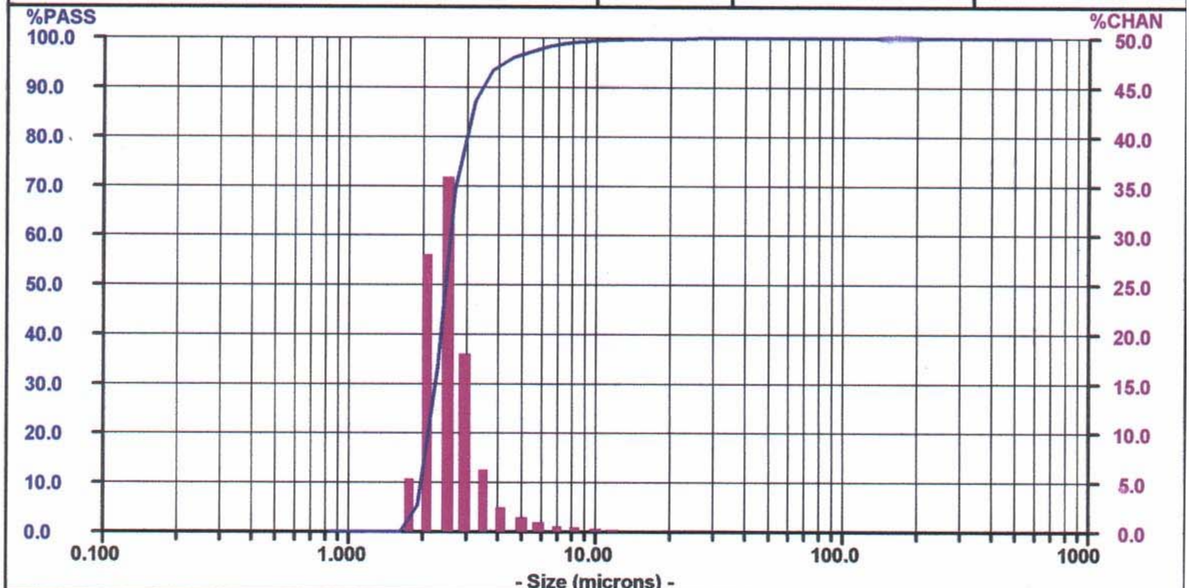
Particle Size

Williams, M.

3-186613
rpp-wtp-prec3b-2sl

Date: 10/29/02 Meas #: 6083
Time: 13:41 Pres #: 1

Summary	Percentiles		Dia	Num%	Width
mv = 9.325	10% = 2.023	60% = 2.617	2.497	100%	1.017
mn = 2.759	20% = 2.156	70% = 2.764			
ma = 4.838	30% = 2.273	80% = 2.989			
cs = 1.240	40% = 2.385	90% = 3.451			
sd = 0.509	50% = 2.497	95% = 4.246			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.00	9.250	99.39	0.40
592.0	100.00	0.00	7.778	98.99	0.63
497.8	100.00	0.00	6.541	98.36	0.95
418.6	100.00	0.00	5.500	97.41	1.41
352.0	100.00	0.00	4.625	96.00	2.49
296.0	100.00	0.00	3.889	93.51	6.21
248.9	100.00	0.00	3.270	87.30	18.00
209.3	100.00	0.00	2.750	69.30	35.83
176.0	100.00	0.00	2.312	33.47	28.05
148.0	100.00	0.00	1.945	5.42	5.42
124.5	100.00	0.00	1.635	0.00	0.00
104.7	100.00	0.00	1.375	0.00	0.00
88.00	100.00	0.00	1.156	0.00	0.00
74.00	100.00	0.00	0.972	0.00	0.00
62.23	100.00	0.00	0.818	0.00	0.00
52.33	100.00	0.00			
44.00	100.00	0.00			
37.00	100.00	0.00			
31.11	100.00	0.00			
26.16	100.00	0.01			
22.00	99.99	0.02			
18.50	99.97	0.05			
15.56	99.92	0.10			
13.08	99.82	0.17			
11.00	99.65	0.26			

SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN

Distribution: Number
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 40
High Resolution: Yes
Filter On: Off

RunTime: 45 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Reflect
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN\PDPSD.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0132
Transmission: 0.96
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-21. Batch 3B AN102R2 slurry four hours after precipitation
(NUMBER Distribution)

MICROTRAC - X100 Ver:7.01

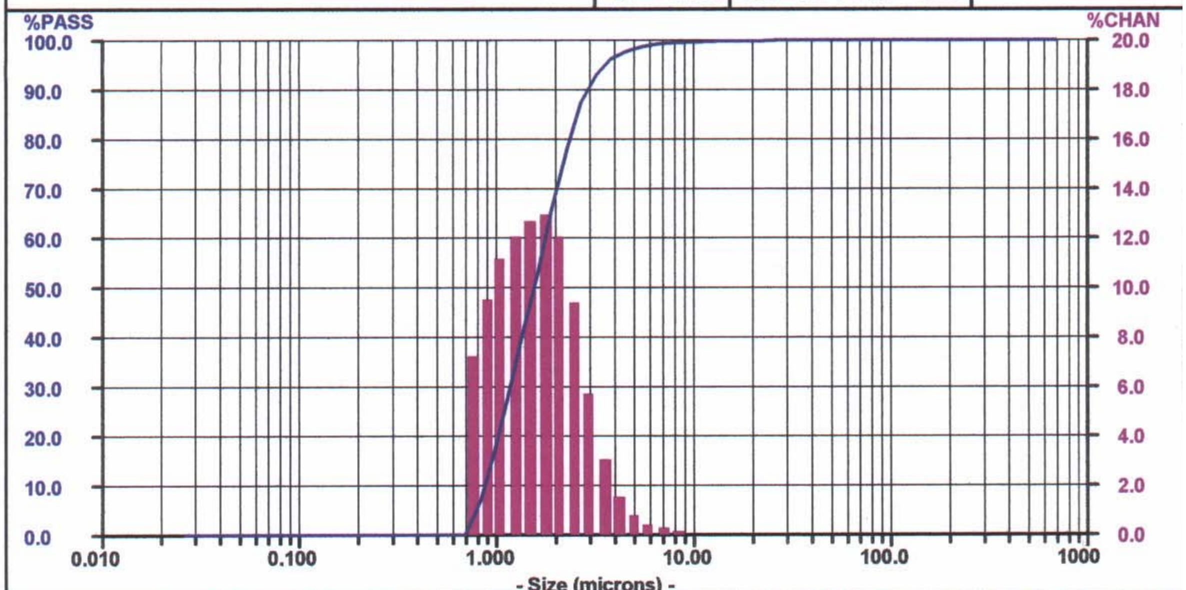
Particle Size Analysis

3-187613
rpp-wtp-prec3b-2sl

Date: 10/28/02 Meas #: 159
Time: 13:03 Pres #: 1

Williams, M.

Summary	Percentiles		Dia	Num%	Width
mv = 9.877	10% = 0.861	60% = 1.795	1.571	100%	1.601
mn = 1.829	20% = 1.022	70% = 2.054			
ma = 4.458	30% = 1.188	80% = 2.384			
cs = 1.346	40% = 1.370	90% = 2.931			
sd = 0.801	50% = 1.571	95% = 3.550			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.00	9.250	99.73	0.18	0.122	0.00	0.00			
592.0	100.00	0.00	7.778	99.55	0.29	0.102	0.00	0.00			
497.8	100.00	0.00	6.541	99.26	0.49	0.086	0.00	0.00			
418.6	100.00	0.00	5.500	98.77	0.85	0.072	0.00	0.00			
352.0	100.00	0.00	4.625	97.92	1.57	0.061	0.00	0.00			
296.0	100.00	0.00	3.889	96.35	3.07	0.051	0.00	0.00			
248.9	100.00	0.00	3.270	93.28	5.77	0.043	0.00	0.00			
209.3	100.00	0.00	2.750	87.51	9.37	0.036	0.00	0.00			
176.0	100.00	0.00	2.312	78.14	12.15	0.030	0.00	0.00			
148.0	100.00	0.00	1.945	65.99	13.01	0.026	0.00	0.00			
124.5	100.00	0.00	1.635	52.98	12.72						
104.7	100.00	0.00	1.375	40.26	12.12						
88.00	100.00	0.00	1.156	28.14	11.24						
74.00	100.00	0.00	0.972	16.90	9.58						
62.23	100.00	0.00	0.818	7.32	7.32						
52.33	100.00	0.00	0.688	0.00	0.00						
44.00	100.00	0.00	0.578	0.00	0.00						
37.00	100.00	0.00	0.486	0.00	0.00						
31.11	100.00	0.00	0.409	0.00	0.00						
26.16	100.00	0.01	0.344	0.00	0.00						
22.00	99.99	0.01	0.289	0.00	0.00						
18.50	99.98	0.03	0.243	0.00	0.00						
15.56	99.95	0.04	0.204	0.00	0.00						
13.08	99.91	0.07	0.172	0.00	0.00						
11.00	99.84	0.11	0.145	0.00	0.00						

Distribution: Number
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 60
X100 Extended Range: Yes
Filter On: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Reflect
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN\MTWIN.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0171
Transmission: 0.96
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 40
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-22. Batch 3B AN102R2 slurry four hours after precipitation
(NUMBER Distribution)

ver.7.01

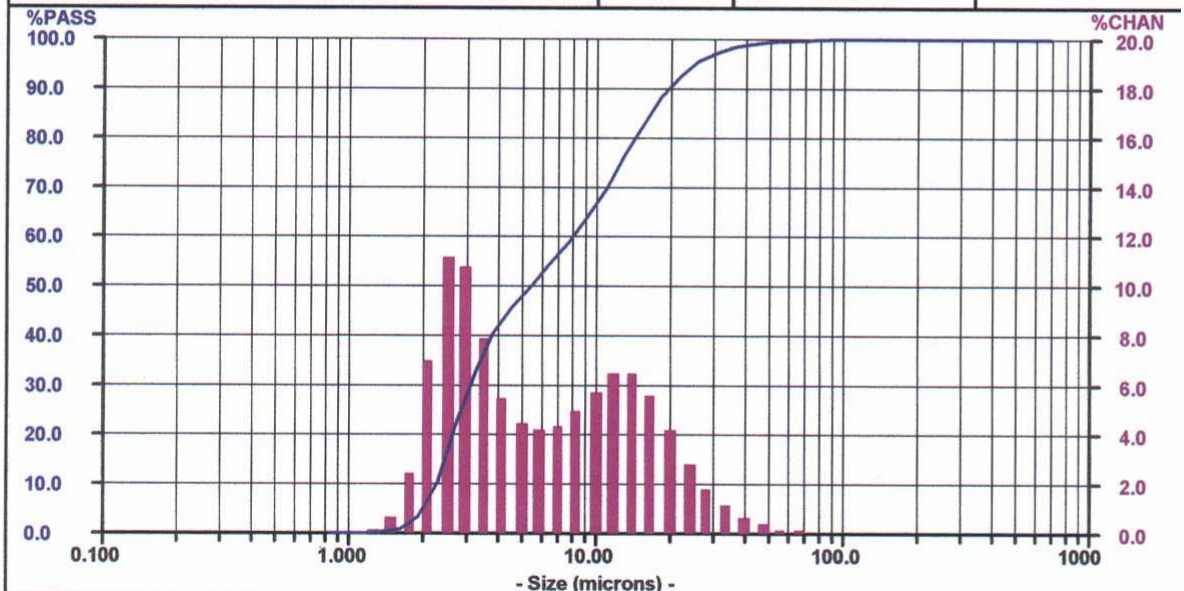
Particle Size

3-186613
rpp-wtp-prec3b-2sl

Date: 10/29/02 Meas #: 6087
Time: 13:45 Pres #: 1

Williams, M.

Summary	Percentiles		Dia	Vol%	Width
mv = 8.952	10% = 2.295	60% = 8.087	12.72	50%	13.81
mn = 2.492	20% = 2.687	70% = 11.07	2.903	50%	1.900
ma = 4.532	30% = 3.135	80% = 14.44			
cs = 1.324	40% = 3.855	90% = 19.62			
sd = 6.793	50% = 5.427	95% = 25.13			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.00	9.250	63.94	5.00						
592.0	100.00	0.00	7.778	58.94	4.42						
497.8	100.00	0.00	6.541	54.52	4.19						
418.6	100.00	0.00	5.500	50.33	4.44						
352.0	100.00	0.00	4.625	45.89	5.54						
296.0	100.00	0.00	3.889	40.35	7.90						
248.9	100.00	0.00	3.270	32.45	10.85						
209.3	100.00	0.00	2.750	21.60	11.21						
176.0	100.00	0.00	2.312	10.39	6.98						
148.0	100.00	0.00	1.945	3.41	2.50						
124.5	100.00	0.00	1.635	0.91	0.64						
104.7	100.00	0.00	1.375	0.27	0.20						
88.00	100.00	0.02	1.156	0.07	0.07						
74.00	99.98	0.15	0.972	0.00	0.00						
62.23	99.83	0.22	0.818	0.00	0.00						
52.33	99.61	0.38									
44.00	99.23	0.66									
37.00	98.57	1.14									
31.11	97.43	1.86									
26.16	95.57	2.91									
22.00	92.66	4.25									
18.50	88.41	5.64									
15.56	82.77	6.51									
13.08	76.26	6.50									
11.00	69.76	5.82									

Distribution: Volume
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 40
High Resolution: Yes
Filter On: Off

RunTime: 45 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN\PDPSD.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0130
Transmission: 0.96
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-23. Batch 3B AN102R2 slurry four hours after precipitation
(VOLUME Distribution)

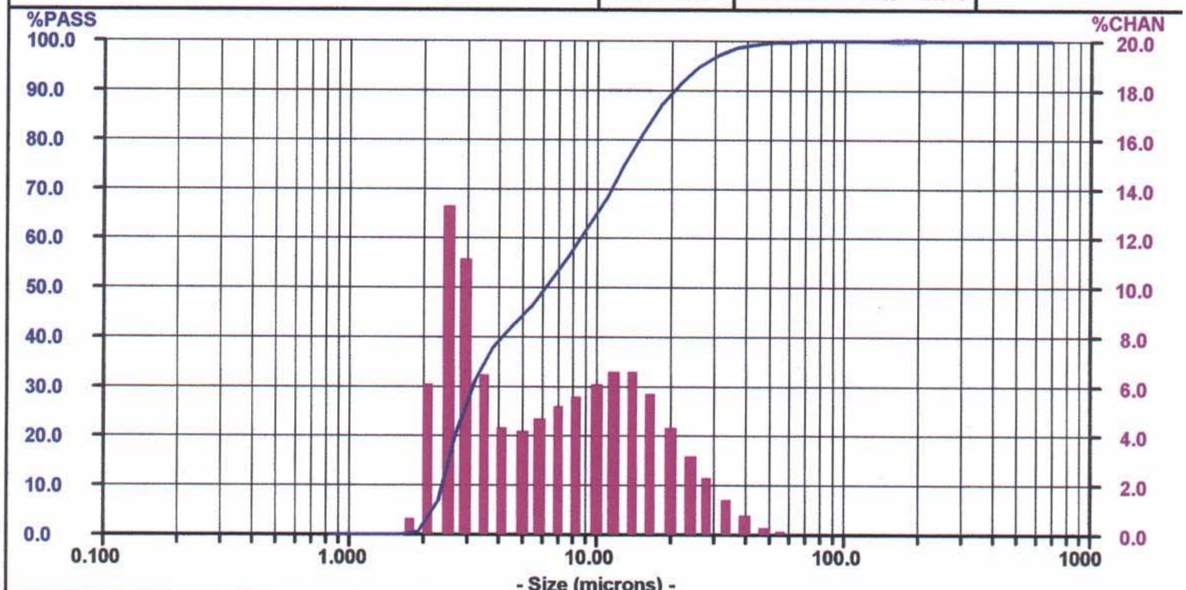
Particle Size

3-186613
rpp-wtp-prec3b-2sl

Date: 10/29/02 Meas #: 6083
Time: 13:41 Pres #: 1

Williams, M.

Summary	Percentiles		Dia	Vol%	Width
mv = 9.325	10% = 2.420	60% = 8.680	11.88	58%	14.55
mn = 2.759	20% = 2.743	70% = 11.52	2.787	42%	1.305
ma = 4.838	30% = 3.187	80% = 14.91			
cs = 1.240	40% = 4.198	90% = 20.49			
sd = 7.035	50% = 6.260	95% = 26.41			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.00	9.250	62.12	5.62						
592.0	100.00	0.00	7.778	56.50	5.25						
497.8	100.00	0.00	6.541	51.25	4.73						
418.6	100.00	0.00	5.500	46.52	4.18						
352.0	100.00	0.00	4.625	42.34	4.40						
296.0	100.00	0.00	3.889	37.94	6.51						
248.9	100.00	0.00	3.270	31.43	11.23						
209.3	100.00	0.00	2.750	20.20	13.30						
176.0	100.00	0.00	2.312	6.90	6.19						
148.0	100.00	0.00	1.945	0.71	0.71						
124.5	100.00	0.00	1.635	0.00	0.00						
104.7	100.00	0.00	1.375	0.00	0.00						
88.00	100.00	0.00	1.156	0.00	0.00						
74.00	100.00	0.02	0.972	0.00	0.00						
62.23	99.98	0.16	0.818	0.00	0.00						
52.33	99.82	0.37									
44.00	99.45	0.81									
37.00	98.64	1.49									
31.11	97.15	2.29									
26.16	94.86	3.21									
22.00	91.65	4.37									
18.50	87.28	5.71									
15.56	81.57	6.63									
13.08	74.94	6.68									
11.00	68.26	6.14									

Distribution: Volume
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 40
High Resolution: Yes
Filter On: Off

RunTime: 45 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Reflect
Particle Refractive Index: N/A
Particle Shape: N/A

Database Path: C:\MTWIN\PDPSD.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0132
Transmission: 0.96
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-24. Batch 3B AN102R2 slurry four hours after precipitation
(VOLUME Distribution)

MICROTRAC - X100 Ver:7.01

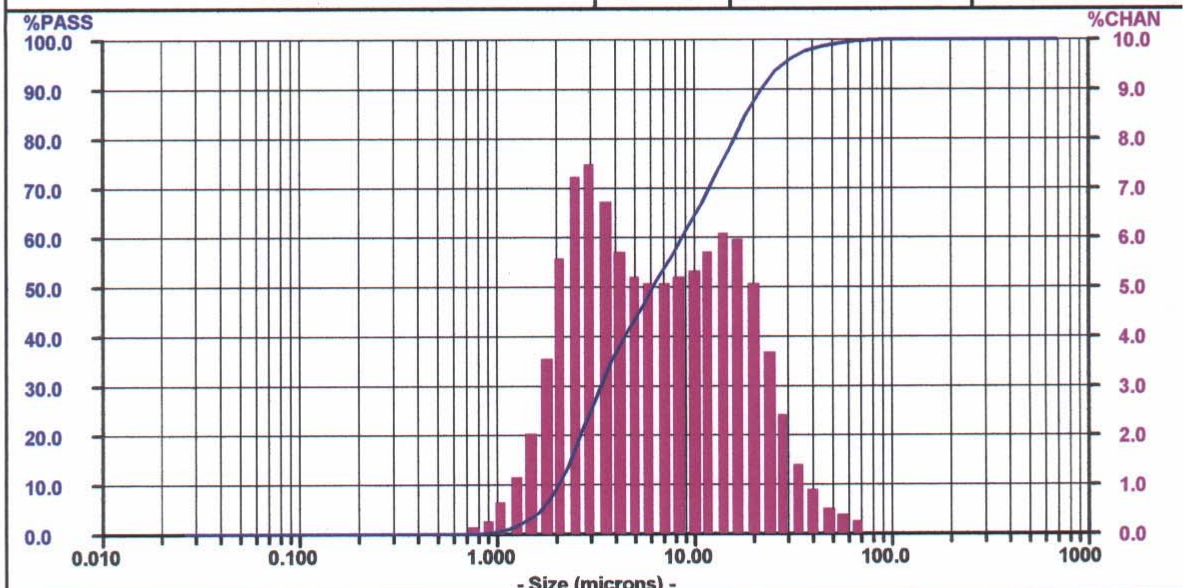
Particle Size Analysis

3-187613
rpp-wtp-prec3b-2sl

Date: 10/28/02 Meas #: 159
Time: 13:03 Pres #: 1

Williams, M.

Summary	Percentiles		Dia	Vol%	Width
mv = 9.877	10% = 2.085	60% = 8.733	13.20	54%	15.87
mn = 1.829	20% = 2.695	70% = 12.03	2.895	46%	2.430
ma = 4.458	30% = 3.396	80% = 16.04			
cs = 1.346	40% = 4.481	90% = 21.94			
sd = 7.772	50% = 6.231	95% = 28.14			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.00	9.250	61.74	5.19	0.122	0.00	0.00			
592.0	100.00	0.00	7.778	56.55	5.12	0.102	0.00	0.00			
497.8	100.00	0.00	6.541	51.43	5.12	0.086	0.00	0.00			
418.6	100.00	0.00	5.500	46.31	5.29	0.072	0.00	0.00			
352.0	100.00	0.00	4.625	41.02	5.81	0.061	0.00	0.00			
296.0	100.00	0.00	3.889	35.21	6.75	0.051	0.00	0.00			
248.9	100.00	0.00	3.270	28.46	7.56	0.043	0.00	0.00			
209.3	100.00	0.00	2.750	20.90	7.30	0.036	0.00	0.00			
176.0	100.00	0.00	2.312	13.60	5.63	0.030	0.00	0.00			
148.0	100.00	0.00	1.945	7.97	3.58	0.026	0.00	0.00			
124.5	100.00	0.00	1.635	4.39	2.08						
104.7	100.00	0.00	1.375	2.31	1.18						
88.00	100.00	0.01	1.156	1.13	0.65						
74.00	99.99	0.33	0.972	0.48	0.33						
62.23	99.66	0.42	0.818	0.15	0.15						
52.33	99.24	0.59	0.688	0.00	0.00						
44.00	98.65	0.90	0.578	0.00	0.00						
37.00	97.75	1.48	0.486	0.00	0.00						
31.11	96.27	2.42	0.409	0.00	0.00						
26.16	93.85	3.77	0.344	0.00	0.00						
22.00	90.08	5.15	0.289	0.00	0.00						
18.50	84.93	6.01	0.243	0.00	0.00						
15.56	78.92	6.08	0.204	0.00	0.00						
13.08	72.84	5.73	0.172	0.00	0.00						
11.00	67.11	5.37	0.145	0.00	0.00						

Distribution: Volume
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 60
X100 Extended Range: Yes
Filter On: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Reflect
Particle Refractive Index: N/A
Particle Shape: N/A

Database Path: C:\MTWIN\MTWIN.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0171
Transmission: 0.96
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 40
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-25. Batch 3B AN102R2 slurry four hours after precipitation
(VOLUME Distribution)

ver:7.01

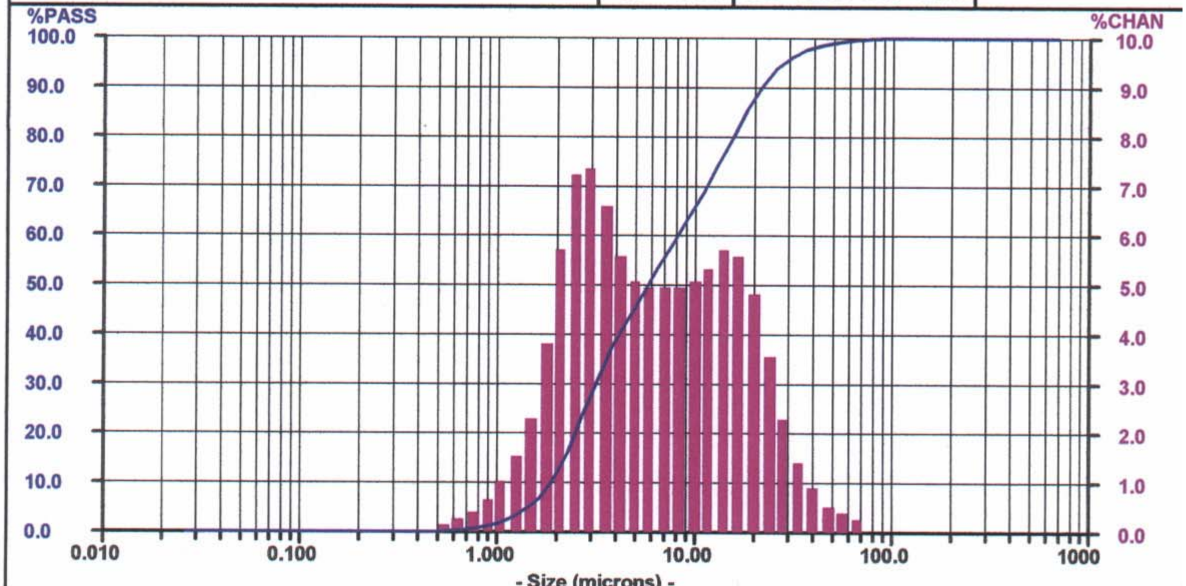
Particle Size Analysis

Williams, M.

3-187613
rpp-wtp-prec3b-2sl

Date: 10/28/02 Meas #: 163
Time: 13:07 Pres #: 1

Summary	Percentiles		Dia	Vol%	Width
mv = 9.561	10% = 1.904	60% = 8.194	14.17	47%	15.77
mn = 1.115	20% = 2.533	70% = 11.48	2.959	53%	3.088
ma = 3.987	30% = 3.192	80% = 15.62			
cs = 1.505	40% = 4.173	90% = 21.66			
sd = 7.667	50% = 5.798	95% = 27.96			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.00	9.250	63.53	5.03	0.122	0.00	0.00			
592.0	100.00	0.00	7.778	58.50	5.01	0.102	0.00	0.00			
497.8	100.00	0.00	6.541	53.49	5.02	0.086	0.00	0.00			
418.6	100.00	0.00	5.500	48.47	5.18	0.072	0.00	0.00			
352.0	100.00	0.00	4.625	43.29	5.68	0.061	0.00	0.00			
296.0	100.00	0.00	3.889	37.61	6.59	0.051	0.00	0.00			
248.9	100.00	0.00	3.270	31.02	7.46	0.043	0.00	0.00			
209.3	100.00	0.00	2.750	23.56	7.27	0.036	0.00	0.00			
176.0	100.00	0.00	2.312	16.29	5.74	0.030	0.00	0.00			
148.0	100.00	0.00	1.945	10.55	3.82	0.026	0.00	0.00			
124.5	100.00	0.00	1.635	6.73	2.40						
104.7	100.00	0.00	1.375	4.33	1.55						
88.00	100.00	0.01	1.156	2.78	1.04						
74.00	99.99	0.35	0.972	1.74	0.69						
62.23	99.64	0.43	0.818	1.05	0.45						
52.33	99.21	0.59	0.688	0.60	0.32						
44.00	98.62	0.89	0.578	0.28	0.25						
37.00	97.73	1.42	0.486	0.03	0.00						
31.11	96.31	2.32	0.409	0.03	0.00						
26.16	93.99	3.58	0.344	0.03	0.01						
22.00	90.41	4.87	0.289	0.02	0.01						
18.50	85.54	5.67	0.243	0.01	0.01						
15.56	79.87	5.74	0.204	0.00	0.00						
13.08	74.13	5.44	0.172	0.00	0.00						
11.00	68.69	5.16	0.145	0.00	0.00						

Distribution: Volume
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 60
X100 Extended Range: Yes
Filter On: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A

Database Path: C:\MTWIN\MTWIN.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0163
Transmission: 0.96
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 40
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-26. Batch 3B AN102R2 slurry four hours after precipitation
(VOLUME Distribution)

ver:7.01

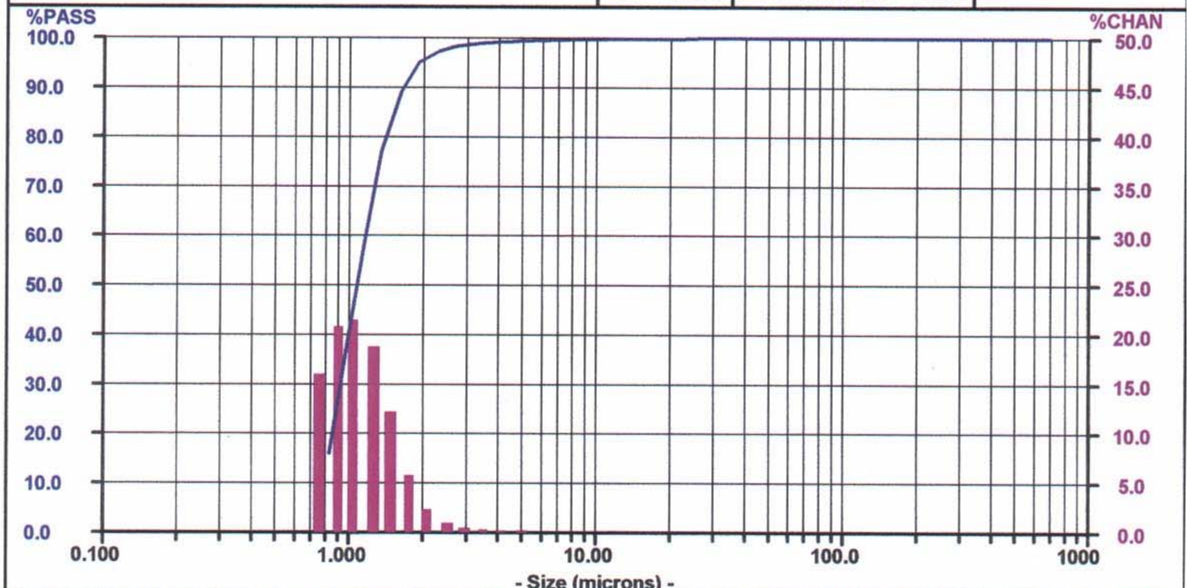
Particle Size

Williams, M.

3-187859
rpp-wtp-prec3a-1sl

Date: 10/29/02 Meas #: 6103
Time: 14:34 Pres #: 1

Summary	Percentiles		Dia	Num%	Width
mv = 125.2	10% = 0.774	60% = 1.173	1.080	100%	0.679
mn = 1.221	20% = 0.848	70% = 1.281			
ma = 14.77	30% = 0.921	80% = 1.422			
cs = 0.406	40% = 0.997	90% = 1.661			
sd = 0.340	50% = 1.080	95% = 1.934			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.00	9.250	99.84	0.06						
592.0	100.00	0.00	7.778	99.78	0.08						
497.8	100.00	0.00	6.541	99.70	0.11						
418.6	100.00	0.00	5.500	99.59	0.16						
352.0	100.00	0.00	4.625	99.43	0.23						
296.0	100.00	0.00	3.889	99.20	0.31						
248.9	100.00	0.00	3.270	98.89	0.49						
209.3	100.00	0.00	2.750	98.40	0.97						
176.0	100.00	0.00	2.312	97.43	2.29						
148.0	100.00	0.00	1.945	95.14	5.82						
124.5	100.00	0.00	1.635	89.32	12.19						
104.7	100.00	0.00	1.375	77.13	18.80						
88.00	100.00	0.00	1.156	58.33	21.50						
74.00	100.00	0.00	0.972	36.83	20.87						
62.23	100.00	0.00	0.818	15.96	15.96						
52.33	100.00	0.00									
44.00	100.00	0.00									
37.00	100.00	0.00									
31.11	100.00	0.00									
26.16	100.00	0.01									
22.00	99.99	0.01									
18.50	99.98	0.02									
15.56	99.96	0.03									
13.08	99.93	0.04									
11.00	99.89	0.05									

Distribution: Number
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 40
High Resolution: Yes
Filter On: Off

RunTime: 45 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN\PDPSD.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0404
Transmission: 0.97
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/A watts
Ultrasonic Time: N/A seconds

Figure I-27. Batch 3A AN102R2 simulant before precipitation
(NUMBER Distribution)

MICROTRAC - SRA150

Ver:7.01

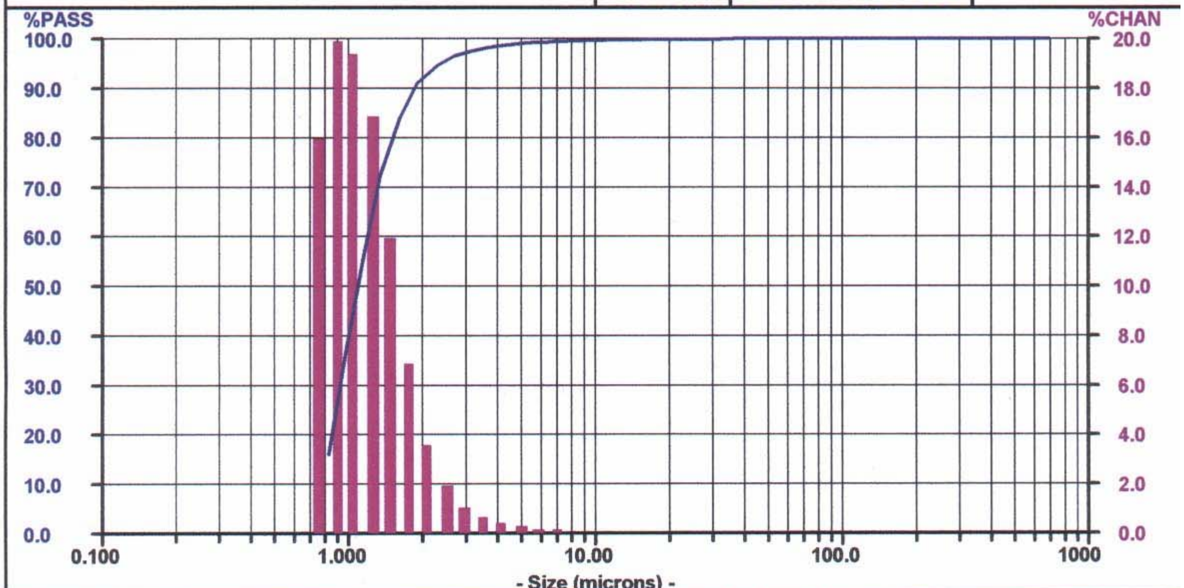
Particle Size

Williams, M.

3-187859
rpp-wtp-prec3a-1sl

Date: 10/29/02 Meas #: 6099
Time: 14:30 Pres #: 1

Summary	Percentiles		Dia	Num%	Width
mv = 121.7	10% = 0.773	60% = 1.208	1.101	100%	0.813
mn = 1.323	20% = 0.848	70% = 1.341			
ma = 18.12	30% = 0.924	80% = 1.526			
cs = 0.331	40% = 1.007	90% = 1.883			
sd = 0.407	50% = 1.101	95% = 2.379			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.00	9.250	99.73	0.11						
592.0	100.00	0.00	7.778	99.62	0.15						
497.8	100.00	0.00	6.541	99.47	0.22						
418.6	100.00	0.00	5.500	99.25	0.34						
352.0	100.00	0.00	4.625	98.91	0.50						
296.0	100.00	0.00	3.889	98.41	0.73						
248.9	100.00	0.00	3.270	97.68	1.13						
209.3	100.00	0.00	2.750	96.55	1.90						
176.0	100.00	0.00	2.312	94.65	3.61						
148.0	100.00	0.00	1.945	91.04	6.87						
124.5	100.00	0.00	1.635	84.17	11.90						
104.7	100.00	0.00	1.375	72.27	16.89						
88.00	100.00	0.00	1.156	55.38	19.43						
74.00	100.00	0.00	0.972	35.95	19.90						
62.23	100.00	0.00	0.818	16.05	16.05						
52.33	100.00	0.00									
44.00	100.00	0.00									
37.00	100.00	0.01									
31.11	99.99	0.01									
26.16	99.98	0.01									
22.00	99.97	0.02									
18.50	99.95	0.03									
15.56	99.92	0.05									
13.08	99.87	0.06									
11.00	99.81	0.08									

Distribution: Number
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 40
High Resolution: Yes
Filter On: Off

RunTime: 45 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Reflect
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN\PDPSD.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0452
Transmission: 0.96
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-28. Batch 3A AN102R2 simulant before precipitation
(NUMBER Distribution)

ver:7.01

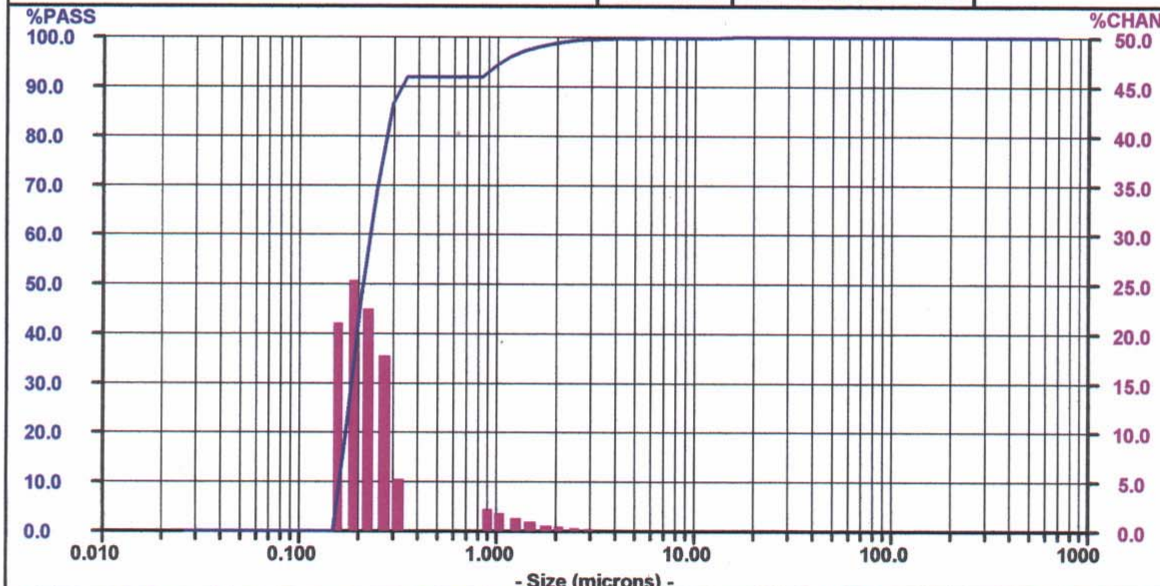
Particle Size Analysis

3-187859
rpp-wtp-prec3a-1sl

Date: 10/28/02 Meas #: 183
Time: 14:10 Pres #: 1

Williams, M.

Summary	Percentiles		Dia	Num%	Width
mv = 135.9	10% = 0.160	60% = 0.226	1.152	8%	0.954
mn = 0.314	20% = 0.171	70% = 0.245	0.203	92%	0.096
ma = 21.69	30% = 0.182	80% = 0.268			
cs = 0.277	40% = 0.196	90% = 0.311			
sd = 0.057	50% = 0.209	95% = 1.041			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.00	9.250	99.97	0.01	0.122	0.00	0.00			
592.0	100.00	0.00	7.778	99.96	0.02	0.102	0.00	0.00			
497.8	100.00	0.00	6.541	99.94	0.03	0.086	0.00	0.00			
418.6	100.00	0.00	5.500	99.91	0.04	0.072	0.00	0.00			
352.0	100.00	0.00	4.625	99.87	0.06	0.061	0.00	0.00			
296.0	100.00	0.00	3.889	99.81	0.10	0.051	0.00	0.00			
248.9	100.00	0.00	3.270	99.71	0.17	0.043	0.00	0.00			
209.3	100.00	0.00	2.750	99.54	0.27	0.036	0.00	0.00			
176.0	100.00	0.00	2.312	99.27	0.42	0.030	0.00	0.00			
148.0	100.00	0.00	1.945	98.85	0.63	0.026	0.00	0.00			
124.5	100.00	0.00	1.635	98.22	0.91						
104.7	100.00	0.00	1.375	97.31	1.28						
88.00	100.00	0.00	1.156	96.03	1.81						
74.00	100.00	0.00	0.972	94.22	2.22						
62.23	100.00	0.00	0.818	92.00	0.00						
52.33	100.00	0.00	0.688	92.00	0.00						
44.00	100.00	0.00	0.578	92.00	0.00						
37.00	100.00	0.00	0.486	92.00	0.00						
31.11	100.00	0.00	0.409	92.00	0.00						
26.16	100.00	0.00	0.344	92.00	5.31						
22.00	100.00	0.00	0.289	86.69	17.83						
18.50	100.00	0.00	0.243	68.86	22.44						
15.56	100.00	0.01	0.204	46.42	25.39						
13.08	99.99	0.01	0.172	21.03	21.03						
11.00	99.98	0.01	0.145	0.00	0.00						

Distribution: Number
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 60
X100 Extended Range: Yes
Filter On: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN\MTWIN.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0394
Transmission: 0.98
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 40
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-29. Batch 3A AN102R2 simulant before precipitation
(NUMBER Distribution)

ver:7.01

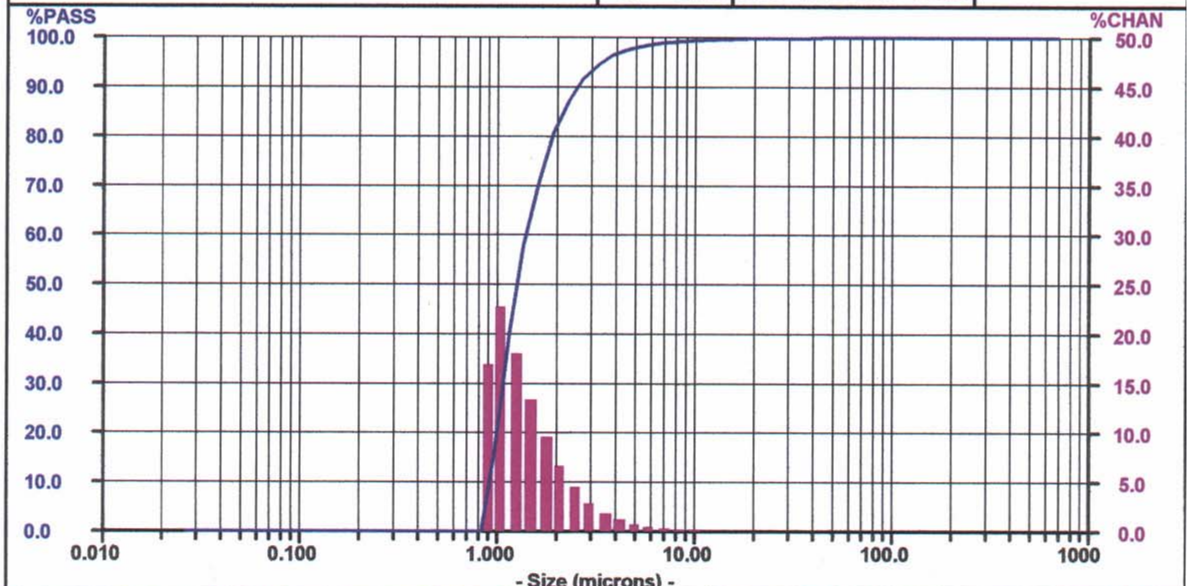
Particle Size Analysis

3-187859
rpp-wtp-prec3a-1sl

Date: 10/28/02 Meas #: 179
Time: 14:07 Pres #: 1

Williams, M.

Summary	Percentiles		Dia	Num%	Width
mv = 136.3	10% = 0.918	60% = 1.413	1.269	100%	1.143
mn = 1.653	20% = 0.995	70% = 1.610			
ma = 27.13	30% = 1.073	80% = 1.920			
cs = 0.221	40% = 1.159	90% = 2.551			
sd = 0.572	50% = 1.269	95% = 3.366			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.00	9.250	99.44	0.23	0.122	0.00	0.00			
592.0	100.00	0.00	7.778	99.21	0.33	0.102	0.00	0.00			
497.8	100.00	0.00	6.541	98.88	0.49	0.086	0.00	0.00			
418.6	100.00	0.00	5.500	98.39	0.75	0.072	0.00	0.00			
352.0	100.00	0.00	4.625	97.64	1.16	0.061	0.00	0.00			
296.0	100.00	0.00	3.889	96.48	1.82	0.051	0.00	0.00			
248.9	100.00	0.00	3.270	94.66	2.90	0.043	0.00	0.00			
209.3	100.00	0.00	2.750	91.76	4.50	0.036	0.00	0.00			
176.0	100.00	0.00	2.312	87.26	6.62	0.030	0.00	0.00			
148.0	100.00	0.00	1.945	80.64	9.55	0.026	0.00	0.00			
124.5	100.00	0.00	1.635	71.09	13.39						
104.7	100.00	0.00	1.375	57.70	18.00						
88.00	100.00	0.00	1.156	39.70	22.75						
74.00	100.00	0.00	0.972	16.95	16.95						
62.23	100.00	0.00	0.818	0.00	0.00						
52.33	100.00	0.00	0.688	0.00	0.00						
44.00	100.00	0.01	0.578	0.00	0.00						
37.00	99.99	0.01	0.486	0.00	0.00						
31.11	99.98	0.02	0.409	0.00	0.00						
26.16	99.96	0.03	0.344	0.00	0.00						
22.00	99.93	0.05	0.289	0.00	0.00						
18.50	99.88	0.07	0.243	0.00	0.00						
15.56	99.81	0.09	0.204	0.00	0.00						
13.08	99.72	0.12	0.172	0.00	0.00						
11.00	99.60	0.16	0.145	0.00	0.00						

Distribution: Number
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 60
X100 Extended Range: Yes
Filter On: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Reflect
Particle Refractive Index: N/A
Particle Shape: N/A

Database Path: C:\MTWIN\MTWIN.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0414
Transmission: 0.98
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 40
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-30. Batch 3A AN102R2 simulant before precipitation
(NUMBER Distribution)

ver:7.01

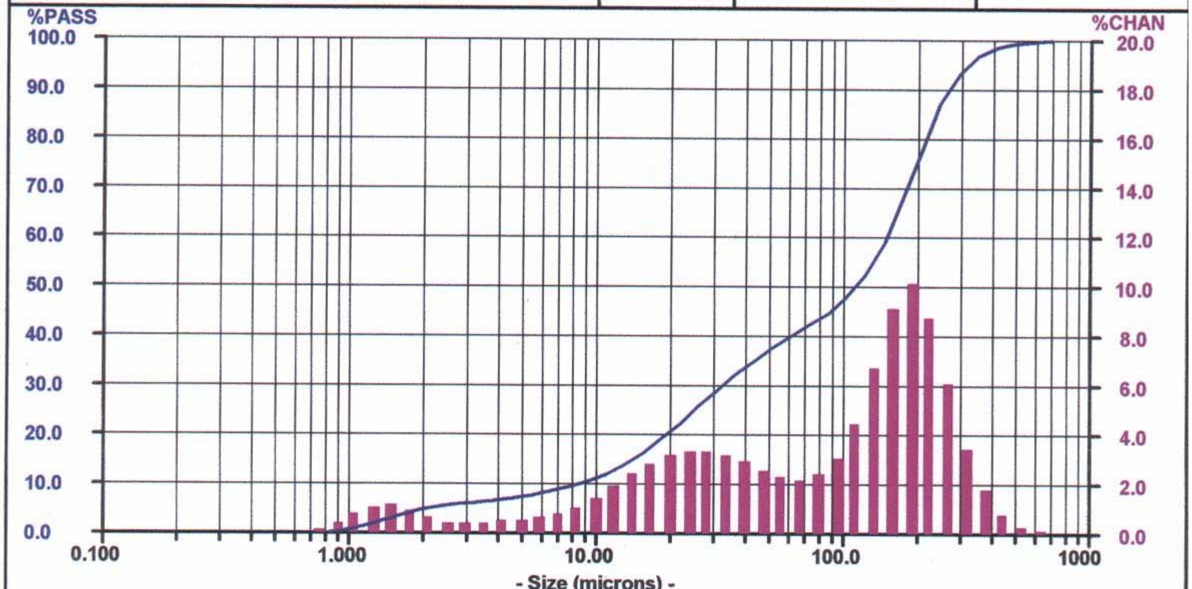
Particle Size

3-187859
rpp-wtp-prec3a-1sl

Date: 10/29/02 Meas #: 6103
Time: 14:34 Pres #: 1

Williams, M.

Summary	Percentiles		Dia	Vol%	Width
mv = 125.2	10% = 8.621	60% = 150.5	181.2	60%	157.0
mn = 1.221	20% = 19.32	70% = 181.1	22.65	34%	32.32
ma = 14.77	30% = 32.83	80% = 215.3	1.456	6%	0.972
cs = 0.406	40% = 61.95	90% = 266.8			
sd = 108.5	50% = 114.3	95% = 317.0			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.16	9.250	10.48	1.10						
592.0	99.84	0.35	7.778	9.38	0.88						
497.8	99.49	0.79	6.541	8.50	0.73						
418.6	98.70	1.80	5.500	7.77	0.62						
352.0	96.90	3.54	4.625	7.15	0.51						
296.0	93.36	6.11	3.889	6.64	0.42						
248.9	87.25	8.78	3.270	6.22	0.39						
209.3	78.47	10.13	2.750	5.83	0.46						
176.0	68.34	9.15	2.312	5.37	0.65						
148.0	59.19	6.74	1.945	4.72	0.98						
124.5	52.45	4.52	1.635	3.74	1.22						
104.7	47.93	3.14	1.375	2.52	1.12						
88.00	44.79	2.47	1.156	1.40	0.76						
74.00	42.32	2.26	0.972	0.64	0.44						
62.23	40.06	2.34	0.818	0.20	0.20						
52.33	37.72	2.61									
44.00	35.11	2.93									
37.00	32.18	3.18									
31.11	29.00	3.30									
26.16	25.70	3.30									
22.00	22.40	3.18									
18.50	19.22	2.91									
15.56	16.31	2.47									
13.08	13.84	1.92									
11.00	11.92	1.44									

Distribution: Volume
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 40
High Resolution: Yes
Filter On: Off

RunTime: 45 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A

Database Path: C:\MTWIN\PDPSD.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0404
Transmission: 0.97
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-31. Batch 3A AN102R2 simulant before precipitation
(VOLUME Distribution)

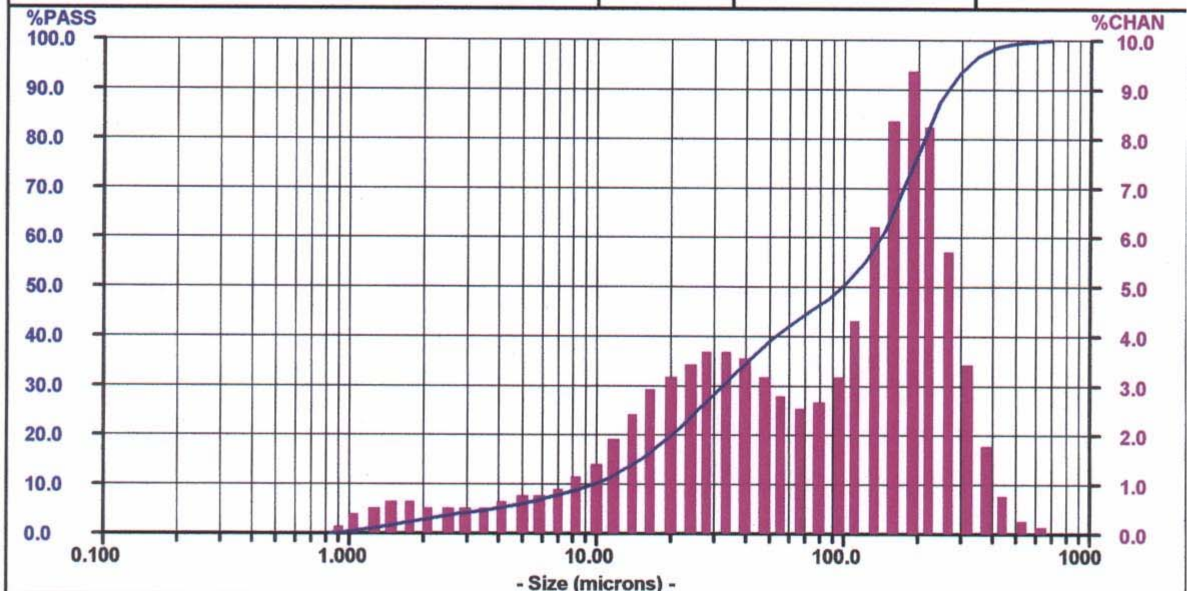
Particle Size

Williams, M.

3-187859
rpp-wtp-prec3a-1sl

Date: 10/29/02 Meas #: 6099
Time: 14:30 Pres #: 1

Summary	Percentiles		Dia	Vol%	Width
mv = 121.7	10% = 9.805	60% = 142.7	180.1	58%	162.8
mn = 1.323	20% = 20.22	70% = 176.2	23.39	39%	34.36
ma = 18.12	30% = 32.74	80% = 212.0	1.490	3%	0.921
cs = 0.331	40% = 54.00	90% = 265.3			
sd = 106.8	50% = 100.6	95% = 317.3			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.19	9.250	9.54	1.18
592.0	99.81	0.37	7.778	8.36	0.98
497.8	99.44	0.82	6.541	7.38	0.86
418.6	98.62	1.79	5.500	6.52	0.78
352.0	96.83	3.43	4.625	5.74	0.68
296.0	93.40	5.82	3.889	5.06	0.59
248.9	87.58	8.24	3.270	4.47	0.54
209.3	79.34	9.40	2.750	3.93	0.54
176.0	69.94	8.45	2.312	3.39	0.61
148.0	61.49	6.31	1.945	2.78	0.69
124.5	55.18	4.37	1.635	2.09	0.71
104.7	50.81	3.19	1.375	1.38	0.60
88.00	47.62	2.68	1.156	0.78	0.41
74.00	44.94	2.62	0.972	0.37	0.25
62.23	42.32	2.86	0.818	0.12	0.12
52.33	39.46	3.23			
44.00	36.23	3.58			
37.00	32.65	3.76			
31.11	28.89	3.72			
26.16	25.17	3.54			
22.00	21.63	3.28			
18.50	18.35	2.92			
15.56	15.43	2.46			
13.08	12.97	1.94			
11.00	11.03	1.49			

SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN

Distribution: Volume
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 40
High Resolution: Yes
Filter On: Off

RunTime: 45 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Reflect
Particle Refractive Index: N/A
Particle Shape: N/A

Database Path: C:\MTWIN\PDPSD.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0452
Transmission: 0.96
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-32. Batch 3A AN102R2 simulant before precipitation
(VOLUME Distribution)

MICROTRAC - X100

Ver:7.01

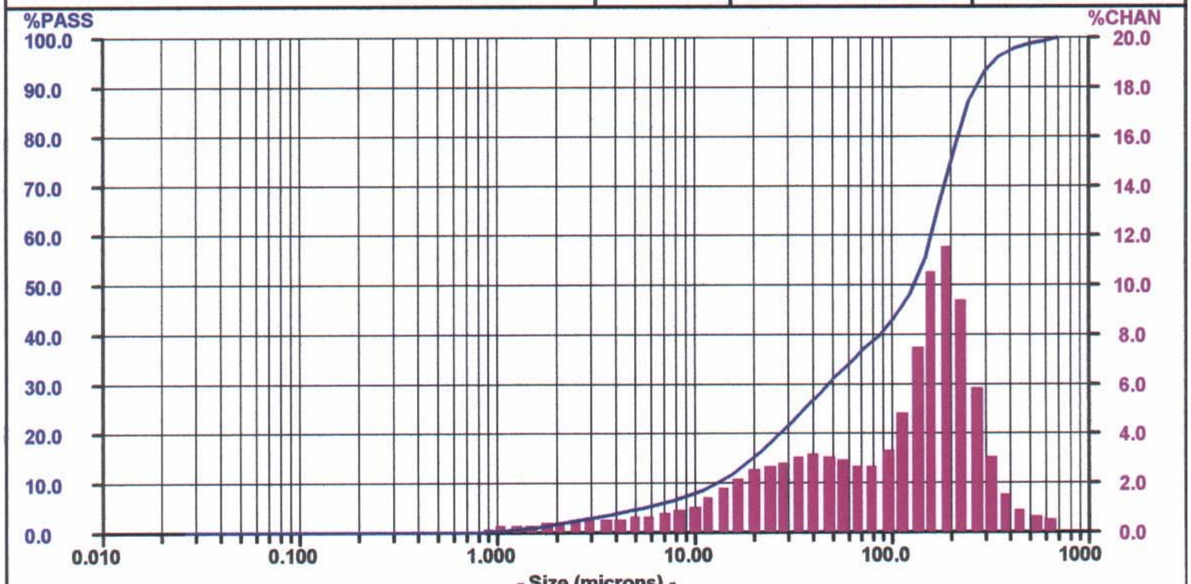
Particle Size Analysis

3-187859
rpp-wtp-prec3a-1sl

Date: 10/28/02 Meas #: 183
Time: 14:10 Pres #: 1

Williams, M.

Summary	Percentiles		Dia	Vol%	Width
mv = 135.9	10% = 13.12	60% = 159.6	178.7	65%	151.0
mn = 0.314	20% = 27.26	70% = 186.1	22.99	35%	39.17
ma = 21.69	30% = 47.94	80% = 216.9			
cs = 0.277	40% = 88.10	90% = 266.6			
sd = 105.8	50% = 130.8	95% = 322.5			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.56	9.250	7.43	0.92	0.122	0.00	0.00			
592.0	99.44	0.65	7.778	6.51	0.79	0.102	0.00	0.00			
497.8	98.79	0.91	6.541	5.72	0.70	0.086	0.00	0.00			
418.6	97.88	1.58	5.500	5.02	0.64	0.072	0.00	0.00			
352.0	96.30	3.10	4.625	4.38	0.59	0.061	0.00	0.00			
296.0	93.20	5.92	3.889	3.79	0.57	0.051	0.00	0.00			
248.9	87.28	9.45	3.270	3.22	0.54	0.043	0.00	0.00			
209.3	77.83	11.60	2.750	2.68	0.52	0.036	0.00	0.00			
176.0	66.23	10.55	2.312	2.16	0.48	0.030	0.00	0.00			
148.0	55.68	7.54	1.945	1.68	0.43	0.026	0.00	0.00			
124.5	48.14	4.83	1.635	1.25	0.37						
104.7	43.31	3.33	1.375	0.88	0.31						
88.00	39.98	2.74	1.156	0.57	0.26						
74.00	37.24	2.72	0.972	0.31	0.19						
62.23	34.52	2.94	0.818	0.12	0.00						
52.33	31.58	3.16	0.688	0.12	0.00						
44.00	28.42	3.17	0.578	0.12	0.00						
37.00	25.25	3.04	0.486	0.12	0.00						
31.11	22.21	2.88	0.409	0.12	0.00						
26.16	19.33	2.76	0.344	0.12	0.02						
22.00	16.57	2.56	0.289	0.10	0.04						
18.50	14.01	2.23	0.243	0.06	0.03						
15.56	11.78	1.81	0.204	0.03	0.02						
13.08	9.97	1.42	0.172	0.01	0.01						
11.00	8.55	1.12	0.145	0.00	0.00						

Distribution: Volume
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 60
X100 Extended Range: Yes
Filter On: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN\MTWIN.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0394
Transmission: 0.98
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 40
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-33. Batch 3A AN102R2 simulant before precipitation
(VOLUME Distribution)

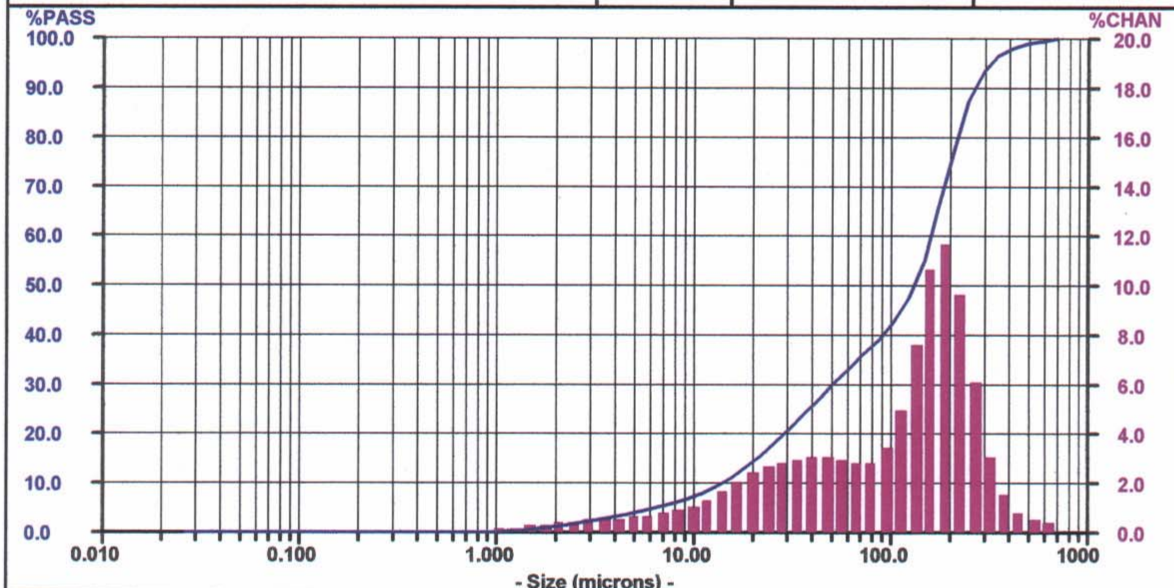
Particle Size Analysis

3-187859
rpp-wtp-prec3a-1sl

Date: 10/28/02 Meas #: 179
Time: 14:07 Pres #: 1

Williams, M.

Summary	Percentiles		Dia	Vol%	Width
mv = 136.3	10% = 14.09	60% = 160.5	178.0	67%	149.6
mn = 1.653	20% = 28.99	70% = 186.7	23.56	33%	39.01
ma = 27.13	30% = 51.13	80% = 217.1			
cs = 0.221	40% = 92.25	90% = 265.0			
sd = 105.1	50% = 132.3	95% = 316.7			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.46	9.250	6.80	0.93	0.122	0.00	0.00			
592.0	99.54	0.55	7.778	5.87	0.80	0.102	0.00	0.00			
497.8	98.99	0.81	6.541	5.07	0.71	0.086	0.00	0.00			
418.6	98.18	1.52	5.500	4.36	0.64	0.072	0.00	0.00			
352.0	96.66	3.14	4.625	3.72	0.59	0.061	0.00	0.00			
296.0	93.52	6.10	3.889	3.13	0.55	0.051	0.00	0.00			
248.9	87.42	9.70	3.270	2.58	0.52	0.043	0.00	0.00			
209.3	77.72	11.76	2.750	2.06	0.48	0.036	0.00	0.00			
176.0	65.96	10.65	2.312	1.58	0.42	0.030	0.00	0.00			
148.0	55.31	7.67	1.945	1.16	0.36	0.026	0.00	0.00			
124.5	47.64	5.00	1.635	0.80	0.30						
104.7	42.64	3.50	1.375	0.50	0.24						
88.00	39.14	2.89	1.156	0.26	0.18						
74.00	36.25	2.83	0.972	0.08	0.08						
62.23	33.42	3.00	0.818	0.00	0.00						
52.33	30.42	3.15	0.688	0.00	0.00						
44.00	27.27	3.12	0.578	0.00	0.00						
37.00	24.15	2.98	0.486	0.00	0.00						
31.11	21.17	2.82	0.409	0.00	0.00						
26.16	18.35	2.68	0.344	0.00	0.00						
22.00	15.67	2.47	0.289	0.00	0.00						
18.50	13.20	2.15	0.243	0.00	0.00						
15.56	11.05	1.75	0.204	0.00	0.00						
13.08	9.30	1.39	0.172	0.00	0.00						
11.00	7.91	1.11	0.145	0.00	0.00						

Distribution: Volume
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 60
X100 Extended Range: Yes
Filter On: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Reflect
Particle Refractive Index: N/A
Particle Shape: N/A

Database Path: C:\MTWIN\MTWIN.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0414
Transmission: 0.98
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 40
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-34. Batch 3A AN102R2 simulant before precipitation
(VOLUME Distribution)

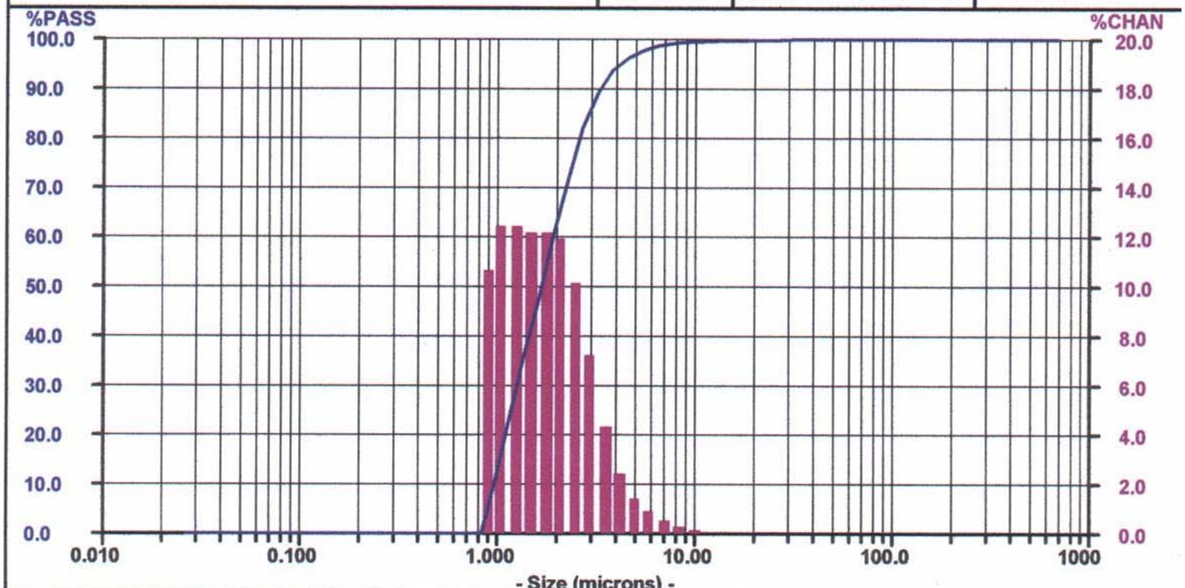
Particle Size Analysis

Williams, M.

3-187860
rpp-wtp-prec3a-2sl

Date: 11/11/02 Meas #: 219
Time: 16:11 Pres #: 1

Summary	Percentiles		Dia	Num%	Width
mv = 11.88	10% = 0.964	60% = 1.943	2.172	64%	1.700
mn = 2.035	20% = 1.108	70% = 2.243	1.075	36%	0.362
ma = 5.691	30% = 1.273	80% = 2.635			
cs = 1.054	40% = 1.464	90% = 3.325			
sd = 0.901	50% = 1.687	95% = 4.161			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.00	9.250	99.59	0.27	0.122	0.00	0.00			
592.0	100.00	0.00	7.778	99.32	0.53	0.102	0.00	0.00			
497.8	100.00	0.00	6.541	98.79	0.92	0.086	0.00	0.00			
418.6	100.00	0.00	5.500	97.87	1.50	0.072	0.00	0.00			
352.0	100.00	0.00	4.625	96.37	2.51	0.061	0.00	0.00			
296.0	100.00	0.00	3.889	93.86	4.37	0.051	0.00	0.00			
248.9	100.00	0.00	3.270	89.49	7.24	0.043	0.00	0.00			
209.3	100.00	0.00	2.750	82.25	10.24	0.036	0.00	0.00			
176.0	100.00	0.00	2.312	72.01	11.96	0.030	0.00	0.00			
148.0	100.00	0.00	1.945	60.05	12.25	0.026	0.00	0.00			
124.5	100.00	0.00	1.635	47.80	12.24						
104.7	100.00	0.00	1.375	35.56	12.50						
88.00	100.00	0.00	1.156	23.06	12.41						
74.00	100.00	0.00	0.972	10.65	10.65						
62.23	100.00	0.00	0.818	0.00	0.00						
52.33	100.00	0.00	0.688	0.00	0.00						
44.00	100.00	0.00	0.578	0.00	0.00						
37.00	100.00	0.00	0.486	0.00	0.00						
31.11	100.00	0.01	0.409	0.00	0.00						
26.16	99.99	0.03	0.344	0.00	0.00						
22.00	99.96	0.05	0.289	0.00	0.00						
18.50	99.91	0.05	0.243	0.00	0.00						
15.56	99.86	0.06	0.204	0.00	0.00						
13.08	99.80	0.08	0.172	0.00	0.00						
11.00	99.72	0.13	0.145	0.00	0.00						

Distribution: Number
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 60
X100 Extended Range: Yes
Filter On: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Reflect
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN\MTWIN.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0254
Transmission: 0.95
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 40
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-35. Batch 3A AN102R2 slurry four hours after precipitation
(NUMBER Distribution)

ver:7.01

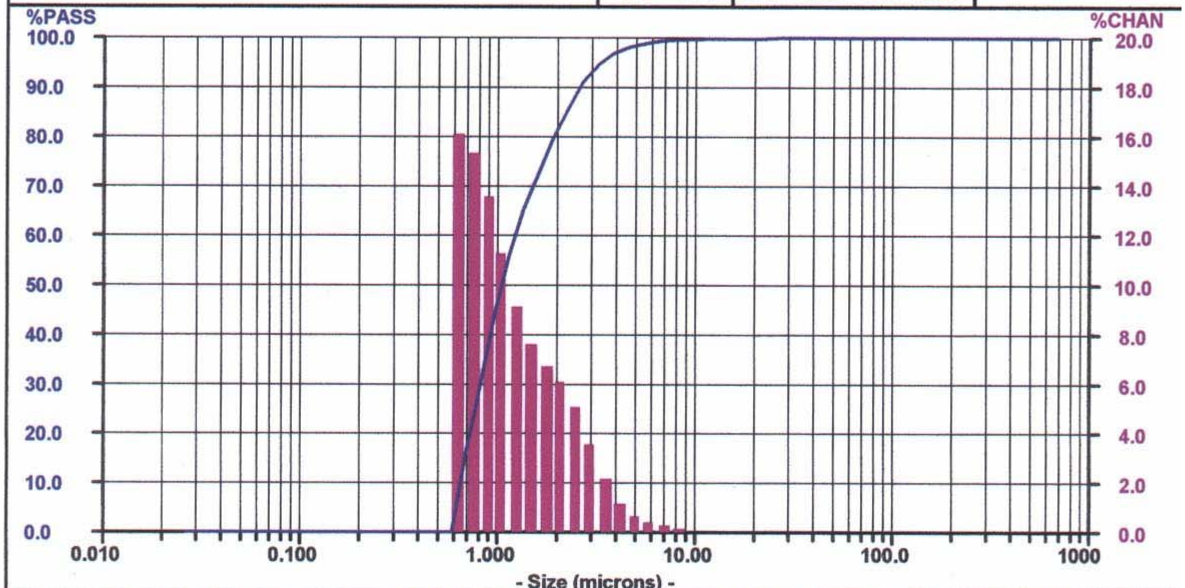
Particle Size Analysis

3-187860
rpp-wtp-prec3a-2sl

Date: 11/11/02 Meas #: 215
Time: 16:08 Pres #: 1

Williams, M.

Summary	Percentiles		Dia	Num%	Width
mv = 11.71	10% = 0.649	60% = 1.236	1.046	100%	1.490
mn = 1.436	20% = 0.717	70% = 1.521			
ma = 5.150	30% = 0.804	80% = 1.952			
cs = 1.165	40% = 0.910	90% = 2.630			
sd = 0.745	50% = 1.046	95% = 3.324			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.00	9.250	99.81	0.14	0.122	0.00	0.00			
592.0	100.00	0.00	7.778	99.67	0.27	0.102	0.00	0.00			
497.8	100.00	0.00	6.541	99.40	0.47	0.086	0.00	0.00			
418.6	100.00	0.00	5.500	98.93	0.75	0.072	0.00	0.00			
352.0	100.00	0.00	4.625	98.18	1.25	0.061	0.00	0.00			
296.0	100.00	0.00	3.889	96.93	2.17	0.051	0.00	0.00			
248.9	100.00	0.00	3.270	94.76	3.58	0.043	0.00	0.00			
209.3	100.00	0.00	2.750	91.18	5.11	0.036	0.00	0.00			
176.0	100.00	0.00	2.312	86.07	6.19	0.030	0.00	0.00			
148.0	100.00	0.00	1.945	79.88	6.82	0.026	0.00	0.00			
124.5	100.00	0.00	1.635	73.06	7.63						
104.7	100.00	0.00	1.375	65.43	9.16						
88.00	100.00	0.00	1.156	56.27	11.30						
74.00	100.00	0.00	0.972	44.97	13.55						
62.23	100.00	0.00	0.818	31.42	15.33						
52.33	100.00	0.00	0.688	16.09	16.09						
44.00	100.00	0.00	0.578	0.00	0.00						
37.00	100.00	0.00	0.486	0.00	0.00						
31.11	100.00	0.00	0.409	0.00	0.00						
26.16	100.00	0.01	0.344	0.00	0.00						
22.00	99.99	0.02	0.289	0.00	0.00						
18.50	99.97	0.02	0.243	0.00	0.00						
15.56	99.95	0.03	0.204	0.00	0.00						
13.08	99.92	0.04	0.172	0.00	0.00						
11.00	99.88	0.07	0.145	0.00	0.00						

Distribution: Number
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 60
X100 Extended Range: Yes
Filter On: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A

Database Path: C:\MTWIN\MTWIN.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0258
Transmission: 0.95
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 40
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-36. Batch 3A AN102R2 slurry four hours after precipitation (NUMBER Distribution)

ver:7.01

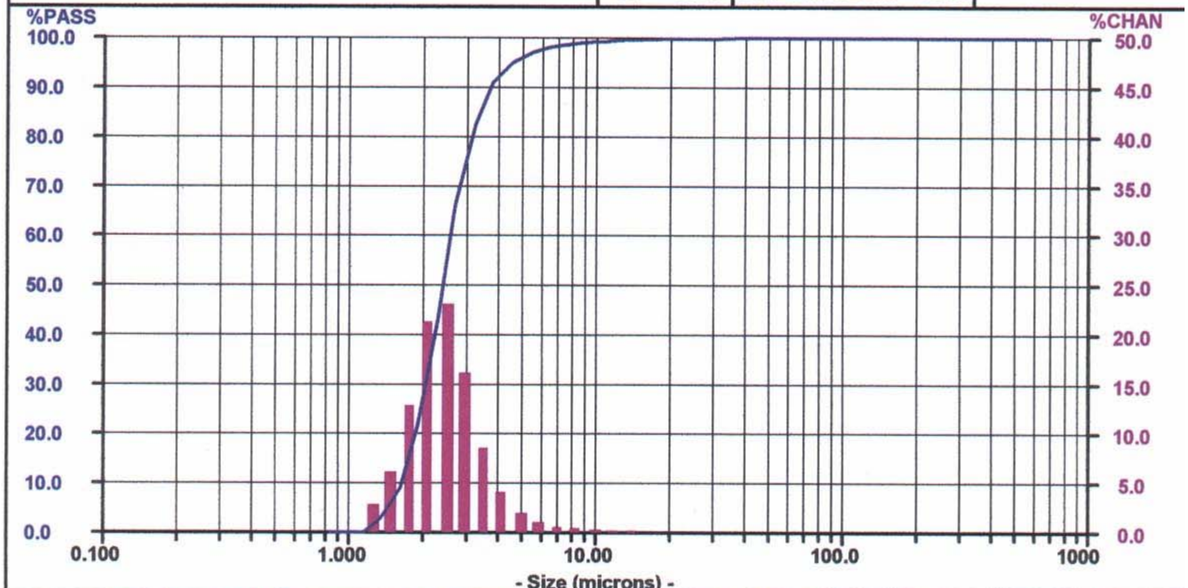
Particle Size

Willams, M.

3-187860
rpp-wtp-prec3a-s2l

Date: 11/11/02 Meas #: 6220
Time: 15:50 Pres #: 1

Summary	Percentiles		Dia	Num%	Width
mv = 18.71	10% = 1.664	60% = 2.615	2.430	100%	1.530
mn = 2.725	20% = 1.906	70% = 2.844			
ma = 6.717	30% = 2.090	80% = 3.166			
cs = 0.893	40% = 2.258	90% = 3.783			
sd = 0.765	50% = 2.430	95% = 4.596			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.00	9.250	99.20	0.39						
592.0	100.00	0.00	7.778	98.81	0.61						
497.8	100.00	0.00	6.541	98.20	1.07						
418.6	100.00	0.00	5.500	97.13	2.01						
352.0	100.00	0.00	4.625	95.12	4.08						
296.0	100.00	0.00	3.889	91.04	8.54						
248.9	100.00	0.00	3.270	82.50	16.18						
209.3	100.00	0.00	2.750	66.32	23.12						
176.0	100.00	0.00	2.312	43.20	21.34						
148.0	100.00	0.00	1.945	21.86	12.85						
124.5	100.00	0.00	1.635	9.01	6.12						
104.7	100.00	0.00	1.375	2.89	2.89						
88.00	100.00	0.00	1.156	0.00	0.00						
74.00	100.00	0.00	0.972	0.00	0.00						
62.23	100.00	0.00	0.818	0.00	0.00						
52.33	100.00	0.00									
44.00	100.00	0.00									
37.00	100.00	0.01									
31.11	99.99	0.02									
26.16	99.97	0.03									
22.00	99.94	0.05									
18.50	99.89	0.09									
15.56	99.80	0.13									
13.08	99.67	0.20									
11.00	99.47	0.27									

Distribution: Number
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 40
High Resolution: Yes
Filter On: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Reflect
Particle Refractive Index: N/A
Particle Shape: N/A

Database Path: C:\MTWIN\PDPSD.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0692
Transmission: 0.86
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

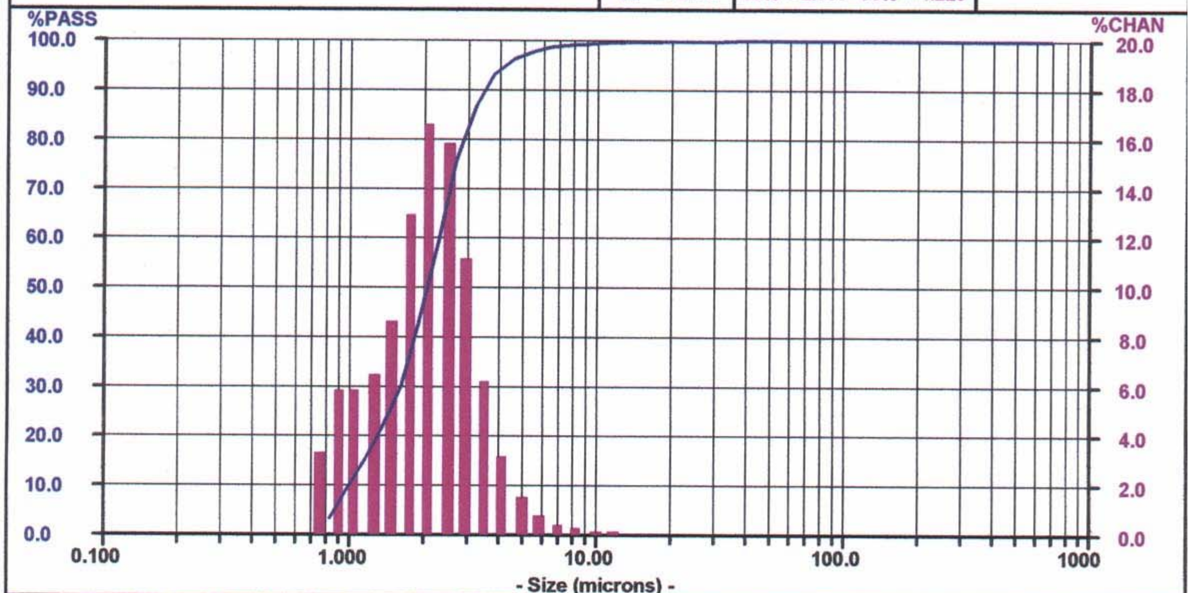
Figure I-37. Batch 3A AN102R2 slurry four hours after precipitation
(NUMBER Distribution)

Ver:7.01

Particle Size	3-187860 rpp-wtp-prec3a-s2l	Date: 11/11/02 Meas #: 6216 Time: 15:47 Pres #: 1

Willams, M.

Summary	Percentiles		Dia	Num%	Width
mv = 17.99	10% = 0.996	60% = 2.317	2.194	91%	1.738
mn = 2.302	20% = 1.325	70% = 2.575	0.860	9%	0.163
ma = 6.327	30% = 1.630	80% = 2.915			
cs = 0.948	40% = 1.873	90% = 3.517			
sd = 0.957	50% = 2.093	95% = 4.229			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.00	9.250	99.46	0.27						
592.0	100.00	0.00	7.778	99.19	0.44						
497.8	100.00	0.00	6.541	98.75	0.81						
418.6	100.00	0.00	5.500	97.94	1.57						
352.0	100.00	0.00	4.625	96.37	3.18						
296.0	100.00	0.00	3.889	93.19	6.29						
248.9	100.00	0.00	3.270	86.90	11.18						
209.3	100.00	0.00	2.750	75.72	15.94						
176.0	100.00	0.00	2.312	59.78	16.59						
148.0	100.00	0.00	1.945	43.19	13.01						
124.5	100.00	0.00	1.635	30.18	8.68						
104.7	100.00	0.00	1.375	21.50	6.48						
88.00	100.00	0.00	1.156	15.02	5.84						
74.00	100.00	0.00	0.972	9.18	5.88						
62.23	100.00	0.00	0.818	3.30	3.30						
52.33	100.00	0.00									
44.00	100.00	0.00									
37.00	100.00	0.01									
31.11	99.99	0.01									
26.16	99.98	0.02									
22.00	99.96	0.04									
18.50	99.92	0.06									
15.56	99.86	0.09									
13.08	99.77	0.13									
11.00	99.64	0.18									

Distribution: Number
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 40
High Resolution: Yes
Filter On: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN\PDPSD.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0698
Transmission: 0.86
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/A watts
Ultrasonic Time: N/A seconds

Figure I-38. Batch 3A AN102R2 slurry four hours after precipitation
(NUMBER Distribution)

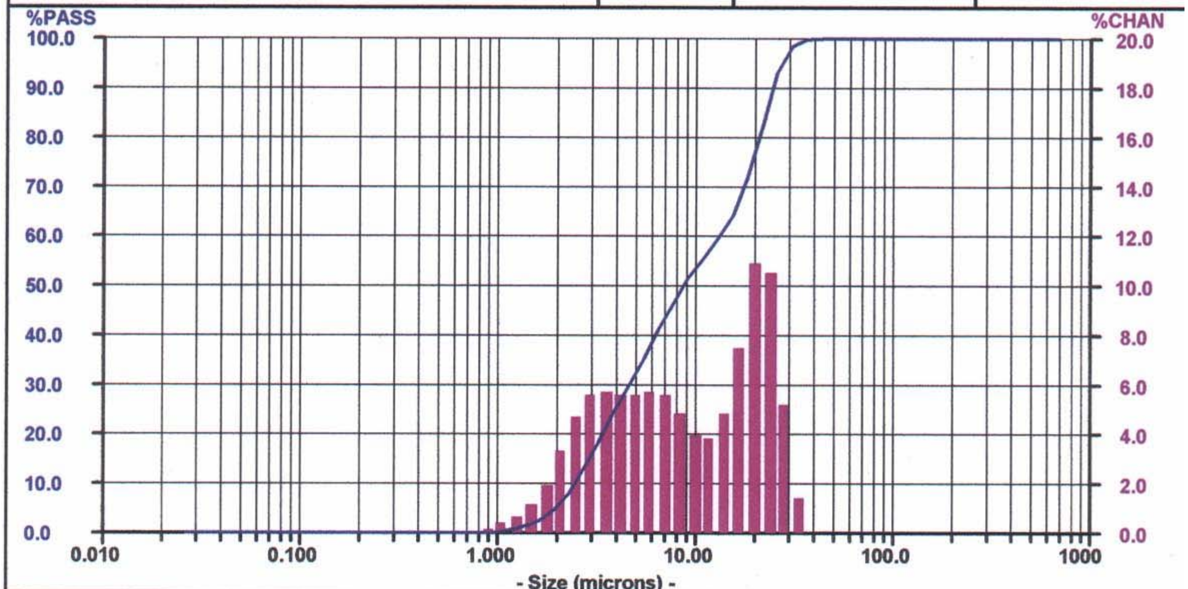
Particle Size Analysis

Williams, M.

3-187860
rpp-wtp-prec3a-2sl

Date: 11/11/02 Meas #: 219
Time: 16:11 Pres #: 1

Summary	Percentiles		Dia	Vol%	Width
mv = 11.88	10% = 2.508	60% = 13.41	20.42	44%	11.15
mn = 2.035	20% = 3.433	70% = 17.88	6.307	31%	4.356
ma = 5.691	30% = 4.668	80% = 21.12	2.694	25%	1.619
cs = 1.054	40% = 6.335	90% = 24.65			
sd = 9.693	50% = 8.729	95% = 27.27			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.00	9.250	51.54	4.86	0.122	0.00	0.00			
592.0	100.00	0.00	7.778	46.68	5.61	0.102	0.00	0.00			
497.8	100.00	0.00	6.541	41.07	5.77	0.086	0.00	0.00			
418.6	100.00	0.00	5.500	35.30	5.59	0.072	0.00	0.00			
352.0	100.00	0.00	4.625	29.71	5.57	0.061	0.00	0.00			
296.0	100.00	0.00	3.889	24.14	5.76	0.051	0.00	0.00			
248.9	100.00	0.00	3.270	18.38	5.68	0.043	0.00	0.00			
209.3	100.00	0.00	2.750	12.70	4.78	0.036	0.00	0.00			
176.0	100.00	0.00	2.312	7.92	3.32	0.030	0.00	0.00			
148.0	100.00	0.00	1.945	4.60	2.02	0.026	0.00	0.00			
124.5	100.00	0.00	1.635	2.58	1.20						
104.7	100.00	0.00	1.375	1.38	0.73						
88.00	100.00	0.00	1.156	0.65	0.43						
74.00	100.00	0.00	0.972	0.22	0.22						
62.23	100.00	0.00	0.818	0.00	0.00						
52.33	100.00	0.00	0.688	0.00	0.00						
44.00	100.00	0.03	0.578	0.00	0.00						
37.00	99.97	1.40	0.486	0.00	0.00						
31.11	98.57	5.31	0.409	0.00	0.00						
26.16	93.26	10.55	0.344	0.00	0.00						
22.00	82.71	10.95	0.289	0.00	0.00						
18.50	71.76	7.54	0.243	0.00	0.00						
15.56	64.22	4.82	0.204	0.00	0.00						
13.08	59.40	3.83	0.172	0.00	0.00						
11.00	55.57	4.03	0.145	0.00	0.00						

Distribution: Volume
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 60
X100 Extended Range: Yes
Filter On: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Reflect
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN\MTWIN.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0254
Transmission: 0.95
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 40
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-39. Batch 3A AN102R2 slurry four hours after precipitation
(VOLUME Distribution)

ver:7.01

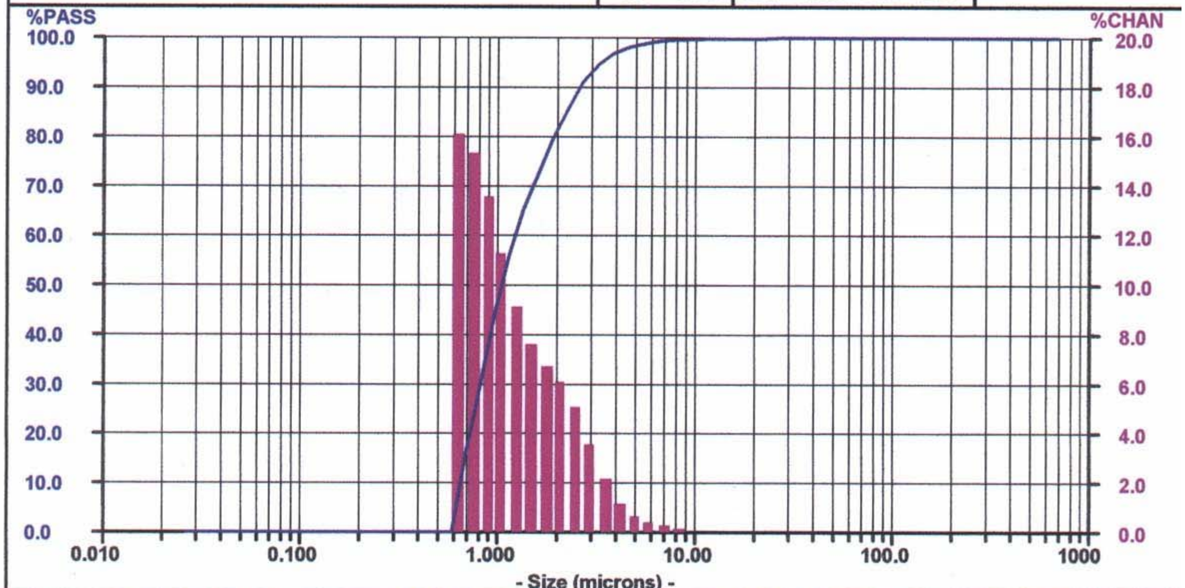
Particle Size Analysis

3-187860
rpp-wtp-prec3a-2sl

Date: 11/11/02 Meas #: 215
Time: 16:08 Pres #: 1

Williams, M.

Summary	Percentiles		Dia	Num%	Width
mv = 11.71	10% = 0.649	60% = 1.236	1.046	100%	1.490
mn = 1.436	20% = 0.717	70% = 1.521			
ma = 5.150	30% = 0.804	80% = 1.952			
cs = 1.165	40% = 0.910	90% = 2.630			
sd = 0.745	50% = 1.046	95% = 3.324			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.00	9.250	99.81	0.14	0.122	0.00	0.00			
592.0	100.00	0.00	7.778	99.67	0.27	0.102	0.00	0.00			
497.8	100.00	0.00	6.541	99.40	0.47	0.086	0.00	0.00			
418.6	100.00	0.00	5.500	98.93	0.75	0.072	0.00	0.00			
352.0	100.00	0.00	4.625	98.18	1.25	0.061	0.00	0.00			
296.0	100.00	0.00	3.889	96.93	2.17	0.051	0.00	0.00			
248.9	100.00	0.00	3.270	94.76	3.58	0.043	0.00	0.00			
209.3	100.00	0.00	2.750	91.18	5.11	0.036	0.00	0.00			
176.0	100.00	0.00	2.312	86.07	6.19	0.030	0.00	0.00			
148.0	100.00	0.00	1.945	79.88	6.82	0.026	0.00	0.00			
124.5	100.00	0.00	1.635	73.06	7.63						
104.7	100.00	0.00	1.375	65.43	9.16						
88.00	100.00	0.00	1.156	56.27	11.30						
74.00	100.00	0.00	0.972	44.97	13.55						
62.23	100.00	0.00	0.818	31.42	15.33						
52.33	100.00	0.00	0.688	16.09	16.09						
44.00	100.00	0.00	0.578	0.00	0.00						
37.00	100.00	0.00	0.486	0.00	0.00						
31.11	100.00	0.00	0.409	0.00	0.00						
26.16	100.00	0.01	0.344	0.00	0.00						
22.00	99.99	0.02	0.289	0.00	0.00						
18.50	99.97	0.02	0.243	0.00	0.00						
15.56	99.95	0.03	0.204	0.00	0.00						
13.08	99.92	0.04	0.172	0.00	0.00						
11.00	99.88	0.07	0.145	0.00	0.00						

Distribution: Number
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 60
X100 Extended Range: Yes
Filter On: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A

Database Path: C:\MTWIN\MTWIN.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0258
Transmission: 0.95
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 40
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-40. Batch 3A AN102R2 slurry four hours after precipitation
(NUMBER Distribution)

ver.7.01

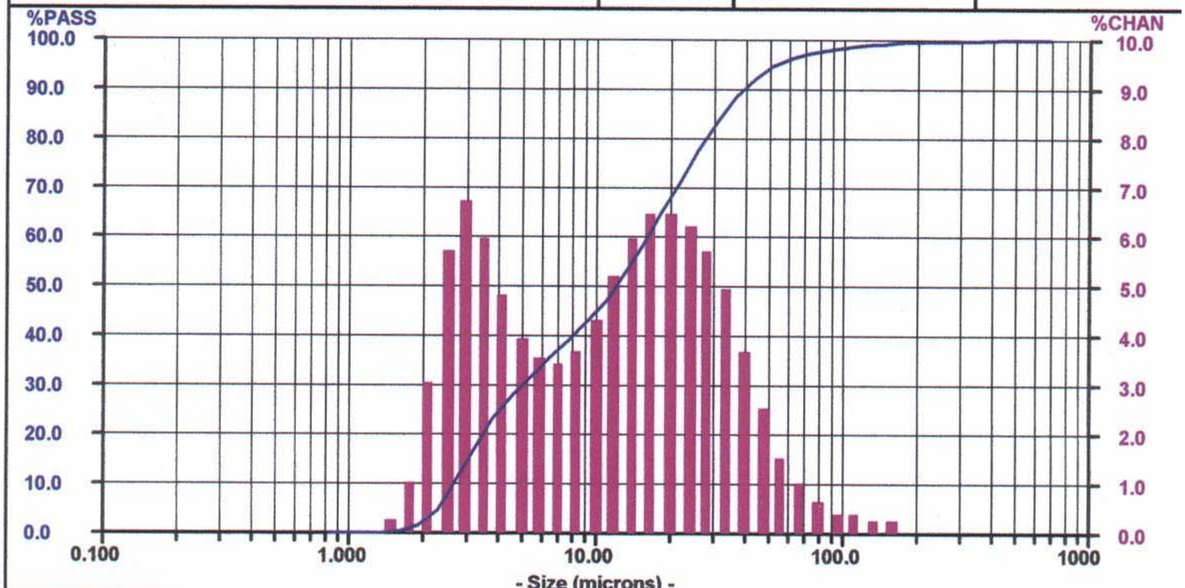
Particle Size

Willams, M.

3-187860
rpp-wtp-prec3a-s2l

Date: 11/11/02 Meas #: 6220
Time: 15:50 Pres #: 1

Summary	Percentiles		Dia	Vol%	Width
mv = 18.71	10% = 2.717	60% = 16.22	19.97	64%	28.52
mn = 2.725	20% = 3.530	70% = 21.17	3.325	36%	2.609
ma = 6.717	30% = 5.014	80% = 27.97			
cs = 0.893	40% = 8.120	90% = 39.55			
sd = 14.23	50% = 12.14	95% = 53.68			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.00	9.250	42.82	3.70
592.0	100.00	0.00	7.778	39.12	3.46
497.8	100.00	0.00	6.541	35.66	3.59
418.6	100.00	0.01	5.500	32.07	4.01
352.0	99.99	0.08	4.625	28.06	4.83
296.0	99.91	0.07	3.889	23.23	6.01
248.9	99.84	0.07	3.270	17.22	6.77
209.3	99.77	0.11	2.750	10.45	5.75
176.0	99.66	0.33	2.312	4.70	3.16
148.0	99.33	0.34	1.945	1.54	1.13
124.5	98.99	0.40	1.635	0.41	0.32
104.7	98.59	0.50	1.375	0.09	0.09
88.00	98.09	0.70	1.156	0.00	0.00
74.00	97.39	1.04	0.972	0.00	0.00
62.23	96.35	1.63	0.818	0.00	0.00
52.33	94.72	2.55			
44.00	92.17	3.74			
37.00	88.43	4.94			
31.11	83.49	5.79			
26.16	77.70	6.26			
22.00	71.44	6.49			
18.50	64.95	6.49			
15.56	58.46	6.07			
13.08	52.39	5.24			
11.00	47.15	4.33			

SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN

Distribution: Volume
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 40
High Resolution: Yes
Filter On: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Reflect
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN\PDPSD.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0692
Transmission: 0.86
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-41. Batch 3A AN102R2 slurry four hours after precipitation
(VOLUME Distribution)

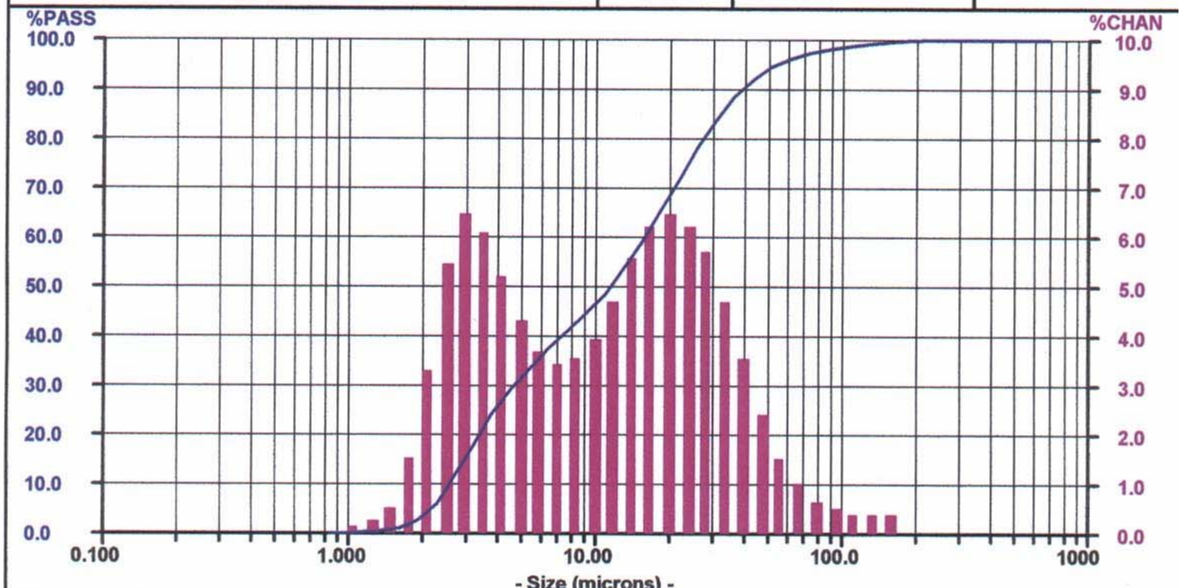
Particle Size

Willams, M.

3-187860
rpp-wtp-prec3a-s2l

Date: 11/11/02 Meas #: 6216
Time: 15:47 Pres #: 1

Summary	Percentiles		Dia	Vol%	Width
mv = 17.99	10% = 2.620	60% = 15.95	20.27	62%	28.81
mn = 2.302	20% = 3.435	70% = 20.91	3.329	38%	2.712
ma = 6.327	30% = 4.703	80% = 27.56			
cs = 0.948	40% = 7.339	90% = 39.29			
sd = 14.06	50% = 11.57	95% = 53.88			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
704.0	100.00	0.00	9.250	44.71	3.55
592.0	100.00	0.00	7.778	41.16	3.48
497.8	100.00	0.00	6.541	37.68	3.77
418.6	100.00	0.00	5.500	33.91	4.35
352.0	100.00	0.00	4.625	29.56	5.22
296.0	100.00	0.00	3.889	24.34	6.15
248.9	100.00	0.00	3.270	18.19	6.50
209.3	100.00	0.06	2.750	11.69	5.51
176.0	99.94	0.40	2.312	6.18	3.41
148.0	99.54	0.39	1.945	2.77	1.59
124.5	99.15	0.44	1.635	1.18	0.63
104.7	98.71	0.55	1.375	0.55	0.28
88.00	98.16	0.75	1.156	0.27	0.15
74.00	97.41	1.09	0.972	0.12	0.09
62.23	96.32	1.64	0.818	0.03	0.03
52.33	94.68	2.47			
44.00	92.21	3.56			
37.00	88.65	4.74			
31.11	83.91	5.70			
26.16	78.21	6.30			
22.00	71.91	6.50			
18.50	65.41	6.28			
15.56	59.13	5.65			
13.08	53.48	4.77			
11.00	48.71	4.00			

SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN

Distribution: Volume
Progression: Standard
Upper Edge: 704.0
Lower Edge: 0.688
Residuals: Disabled
Number Of Channels: 40
High Resolution: Yes
Filter On: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A

Database Path: C:\MTWIN\PDPSD.DB

Fluid: Water
Fluid Refractive Index: N/A
Loading Factor: 0.0698
Transmission: 0.86
Above Residual: 0.00
Below Residual: 0.00

ASVR Flow Rate: 60
Ultrasonic Power: N/Awatts
Ultrasonic Time: N/A seconds

Figure I-42. Batch 3A AN102R2 slurry four hours after precipitation (VOLUME Distribution)

Serial Number: S3261
Range: 0.021 -1408 um

MICROTRAC - S3000

Ver:9.0K
Meas : Original

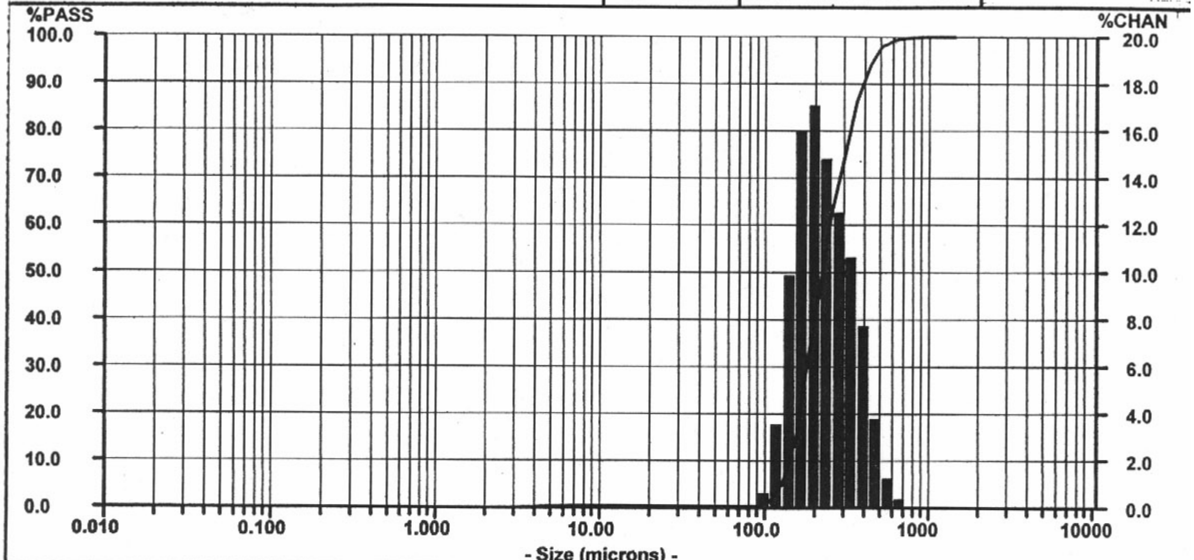
Particle Size Analysis

3-199108
rpp-wtp-prec4a-pfs

Date: 08/12/03 Meas #: 210
Time: 07:49 Pres #: 1

Williams, Michael

Summary	Percentiles		Dia	Vol%	Width
mv = 238.8	10% = 137.8	60% = 239.7	213.7	100%	187.6
mn = 3.197	20% = 157.2	70% = 273.0			
ma = 166.5	30% = 174.3	80% = 316.4			
cs = 0.036	40% = 192.6	90% = 378.0			
sd = 93.78	50% = 213.7	95% = 429.8			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
1408	100.00	0.00	18.50	0.47	0.00	0.243	0.00	0.00			
1184	100.00	0.00	15.56	0.47	0.00	0.204	0.00	0.00			
995.6	100.00	0.00	13.08	0.47	0.00	0.172	0.00	0.00			
837.2	100.00	0.12	11.00	0.47	0.02	0.145	0.00	0.00			
704.0	99.88	0.41	9.250	0.45	0.02	0.122	0.00	0.00			
592.0	99.47	1.37	7.778	0.43	0.04	0.102	0.00	0.00			
497.8	98.10	3.89	6.541	0.39	0.06	0.086	0.00	0.00			
418.6	94.21	7.83	5.500	0.33	0.06	0.072	0.00	0.00			
352.0	86.38	10.74	4.625	0.27	0.06	0.061	0.00	0.00			
296.0	75.64	12.62	3.889	0.21	0.06	0.051	0.00	0.00			
248.9	63.02	14.90	3.270	0.15	0.06	0.043	0.00	0.00			
209.3	48.12	17.15	2.750	0.09	0.06	0.036	0.00	0.00			
176.0	30.97	16.06	2.312	0.03	0.03	0.030	0.00	0.00			
148.0	14.91	9.97	1.945	0.00	0.00	0.026	0.00	0.00			
124.5	4.94	3.63	1.635	0.00	0.00						
104.7	1.31	0.75	1.375	0.00	0.00						
88.00	0.56	0.09	1.156	0.00	0.00						
74.00	0.47	0.00	0.972	0.00	0.00						
62.23	0.47	0.00	0.818	0.00	0.00						
52.33	0.47	0.00	0.688	0.00	0.00						
44.00	0.47	0.00	0.578	0.00	0.00						
37.00	0.47	0.00	0.486	0.00	0.00						
31.11	0.47	0.00	0.409	0.00	0.00						
26.16	0.47	0.00	0.344	0.00	0.00						
22.00	0.47	0.00	0.289	0.00	0.00						

Distribution: Volume
Progression: Standard
Upper Edge: 1408
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 64
Filter: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN90\MTWIN.DB

Fluid: Water
Fluid Refractive Index: 1.33
Loading Factor: 0.0894
Transmission: 0.99
Above Residual: 0.00
Below Residual: 0.00

Analysis Mode: S3000
Sample Cell Id: 0188
ASVR Flow Rate: 75
Ultrasonic Power: 25 watts
Ultrasonic Time: 60 seconds

Figure I-43. Batch 4A AN102R2 post filtration precipitation solids
(VOLUME Distribution)

Serial Number: S3261
Range: 0.021 -1408 um

MICROTRAC - S3000

Ver:9.0K
Meas : Recalc

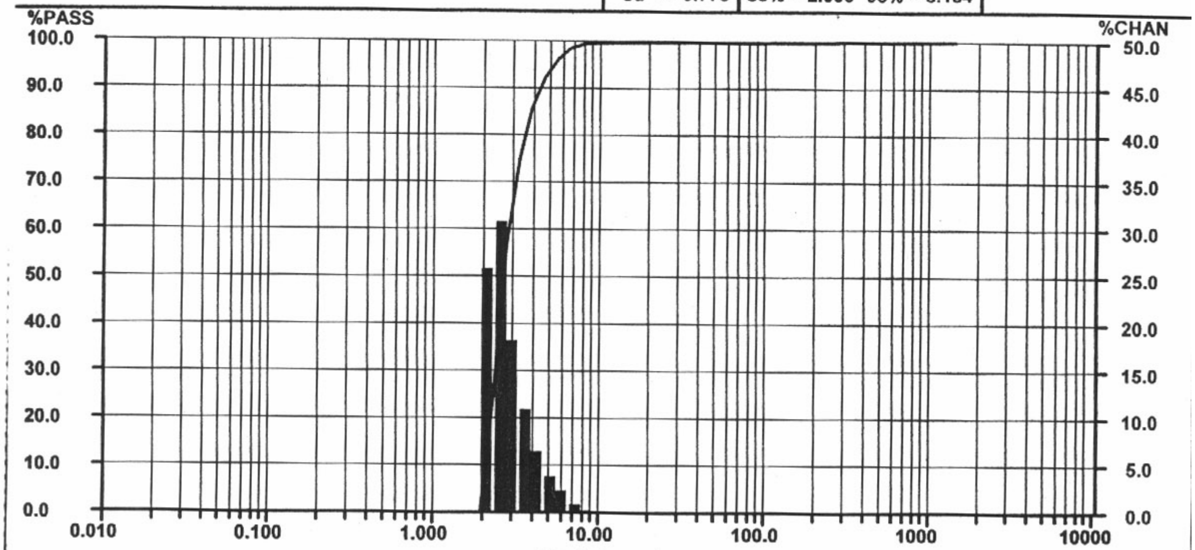
Particle Size Analysis

3-199108
rpp-wtp-prec4a-pfs

Date: 08/12/03 Meas #: 210
Time: 07:49 Pres #: 1

Williams, Michael

Summary	Percentiles		Dia	Num%	Width
mv = 238.8	10% = 2.114	60% = 2.821	2.638	100%	1.556
mn = 3.197	20% = 2.240	70% = 3.088			
ma = 166.5	30% = 2.365	80% = 3.505			
cs = 0.036	40% = 2.495	90% = 4.295			
sd = 0.778	50% = 2.638	95% = 5.154			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
1408	100.00	0.00	18.50	99.87	0.00	0.243	0.00	0.00			
1184	100.00	0.00	15.56	99.87	0.00	0.204	0.00	0.00			
995.6	100.00	0.00	13.08	99.87	0.00	0.172	0.00	0.00			
837.2	100.00	0.00	11.00	99.87	0.16	0.145	0.00	0.00			
704.0	100.00	0.00	9.250	99.71	0.27	0.122	0.00	0.00			
592.0	100.00	0.00	7.778	99.44	0.91	0.102	0.00	0.00			
497.8	100.00	0.00	6.541	98.53	2.29	0.086	0.00	0.00			
418.6	100.00	0.00	5.500	96.24	3.85	0.072	0.00	0.00			
352.0	100.00	0.00	4.625	92.39	6.48	0.061	0.00	0.00			
296.0	100.00	0.01	3.889	85.91	10.90	0.051	0.00	0.00			
248.9	99.99	0.01	3.270	75.01	18.32	0.043	0.00	0.00			
209.3	99.98	0.02	2.750	56.69	30.80	0.036	0.00	0.00			
176.0	99.96	0.03	2.312	25.89	25.89	0.030	0.00	0.00			
148.0	99.93	0.03	1.945	0.00	0.00	0.026	0.00	0.00			
124.5	99.90	0.02	1.635	0.00	0.00						
104.7	99.88	0.01	1.375	0.00	0.00						
88.00	99.87	0.00	1.156	0.00	0.00						
74.00	99.87	0.00	0.972	0.00	0.00						
62.23	99.87	0.00	0.818	0.00	0.00						
52.33	99.87	0.00	0.688	0.00	0.00						
44.00	99.87	0.00	0.578	0.00	0.00						
37.00	99.87	0.00	0.486	0.00	0.00						
31.11	99.87	0.00	0.409	0.00	0.00						
26.16	99.87	0.00	0.344	0.00	0.00						
22.00	99.87	0.00	0.289	0.00	0.00						

Distribution: Number
Progression: Standard
Upper Edge: 1408
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 64
Filter: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN90\MTWIN.DB

Fluid: Water
Fluid Refractive Index: 1.33
Loading Factor: 0.0894
Transmission: 0.99
Above Residual: 0.00
Below Residual: 0.00

Analysis Mode: S3000
Sample Cell Id: 0188
ASVR Flow Rate: 75
Ultrasonic Power: 25 watts
Ultrasonic Time: 60 seconds

Figure I-44. Batch 4A AN102R2 post filtration precipitation solids
(NUMBER Distribution)

erial Number: S3261
ange: 0.021 -1408 um

MICROTRAC - S3000

Ver:9.0K
Meas : Original

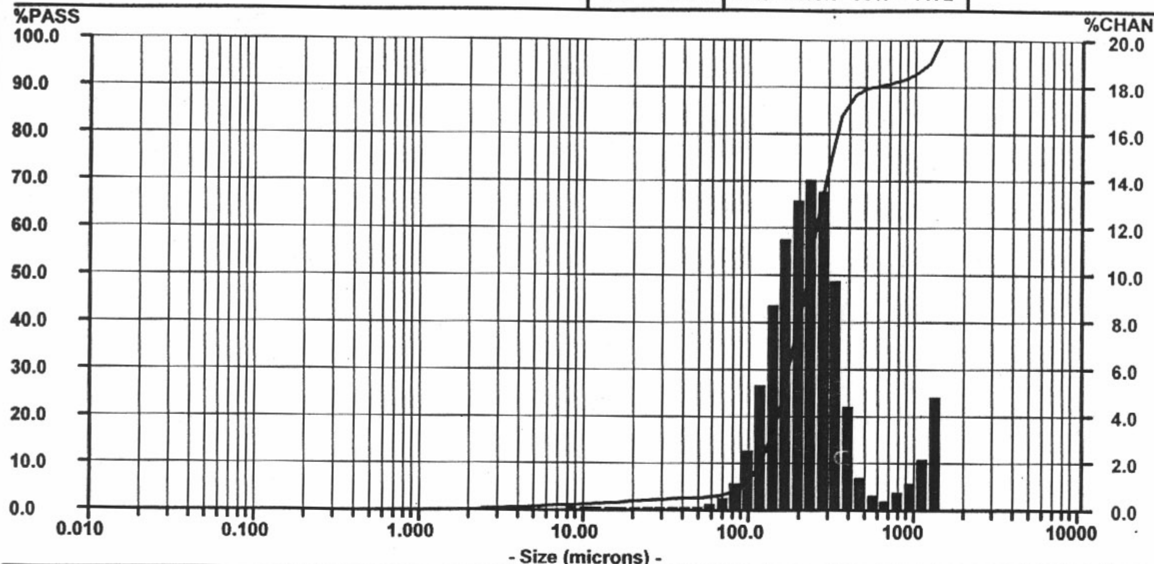
Particle Size Analysis

3-199108
rpp-wtp-prec4a-pfs

Date: 08/12/03 Meas #: 214
Time: 08:01 Pres #: 1

illiams, Michael
d run using larger sampling spatula

Summary	Percentiles		Dia	Vol%	Width
mv = 300.9	10% = 115.0	60% = 247.4	1118	12%	756.6
mn = 2.065	20% = 144.1	70% = 280.0	203.6	88%	168.2
ma = 103.1	30% = 168.4	80% = 324.9			
cs = 0.058	40% = 192.9	90% = 513.5			
sd = 109.5	50% = 218.9	95% = 1172			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
1408	100.00	4.82	18.50	1.96	0.19	0.243	0.00	0.00			
1184	95.18	2.17	15.56	1.77	0.17	0.204	0.00	0.00			
995.6	93.01	1.23	13.08	1.60	0.15	0.172	0.00	0.00			
837.2	91.78	0.80	11.00	1.45	0.14	0.145	0.00	0.00			
704.0	90.98	0.48	9.250	1.31	0.13	0.122	0.00	0.00			
592.0	90.50	0.64	7.778	1.18	0.12	0.102	0.00	0.00			
497.8	89.86	1.45	6.541	1.06	0.12	0.086	0.00	0.00			
418.6	88.41	4.46	5.500	0.94	0.12	0.072	0.00	0.00			
352.0	83.95	9.83	4.625	0.82	0.12	0.061	0.00	0.00			
296.0	74.12	13.61	3.889	0.70	0.13	0.051	0.00	0.00			
248.9	60.51	14.12	3.270	0.57	0.13	0.043	0.00	0.00			
209.3	46.39	13.27	2.750	0.44	0.13	0.036	0.00	0.00			
176.0	33.12	11.57	2.312	0.31	0.11	0.030	0.00	0.00			
148.0	21.55	8.74	1.945	0.20	0.09	0.026	0.00	0.00			
124.5	12.81	5.33	1.635	0.11	0.07						
104.7	7.48	2.65	1.375	0.04	0.04						
88.00	4.83	1.17	1.156	0.00	0.00						
74.00	3.66	0.52	0.972	0.00	0.00						
62.23	3.14	0.26	0.818	0.00	0.00						
52.33	2.88	0.16	0.688	0.00	0.00						
44.00	2.72	0.13	0.578	0.00	0.00						
37.00	2.59	0.13	0.486	0.00	0.00						
31.11	2.46	0.15	0.409	0.00	0.00						
26.16	2.31	0.16	0.344	0.00	0.00						
22.00	2.15	0.19	0.289	0.00	0.00						

Distribution: Volume
Progression: Standard
Upper Edge: 1408
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 64
Filter: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN90\MTWIN.DB

Fluid: Water
Fluid Refractive Index: 1.33
Loading Factor: 0.2890
Transmission: 0.96
Above Residual: 0.00
Below Residual: 0.00

Analysis Mode: S3000
Sample Cell Id: 0188

ASVR Flow Rate: 75
Ultrasonic Power: 25 watts
Ultrasonic Time: 60 seconds

Figure I-45. Batch 4A AN102R2 post filtration precipitation solids
(VOLUME Distribution)

erial Number: S3261
ange: 0.021 -1408 um

MICROTRAC - S3000

Ver:9.0K
Meas : Recalc

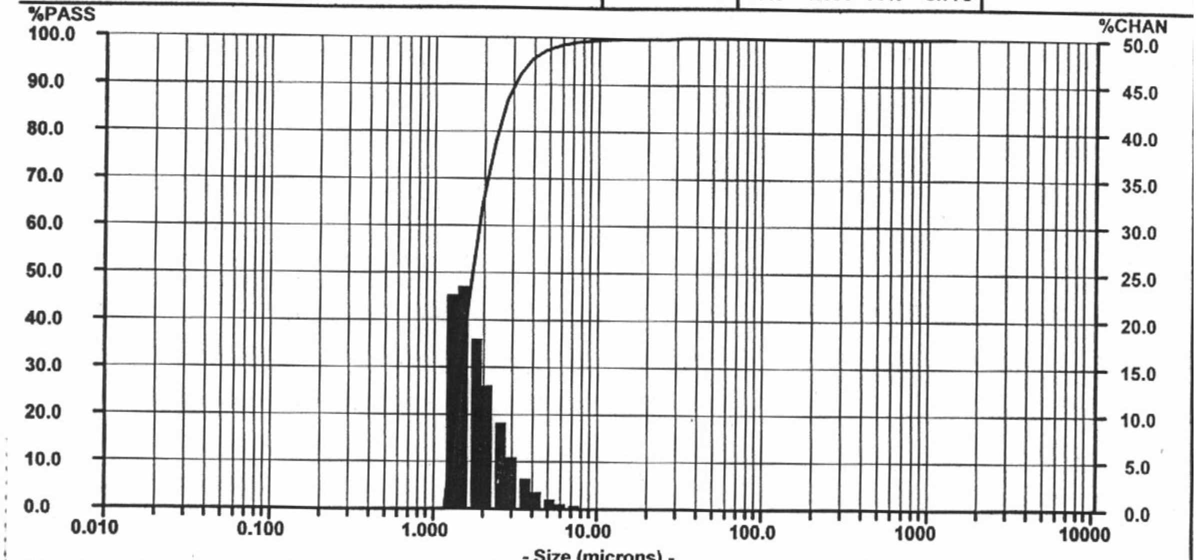
Particle Size Analysis

3-199108
rpp-wtp-prec4a-pfs

Date: 08/12/03 Meas #: 214
Time: 08:03 Pres #: 1

Villiams, Michael
nd run using larger sampling spatula

Summary	Percentiles		Dia	Num%	Width
mv = 300.9	10% = 1.266	60% = 1.855	1.688	100%	1.276
mn = 2.065	20% = 1.352	70% = 2.082			
ma = 103.1	30% = 1.447	80% = 2.409			
cs = 0.058	40% = 1.557	90% = 3.018			
sd = 0.638	50% = 1.688	95% = 3.775			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
1408	100.00	0.00	18.50	99.95	0.04	0.243	0.00	0.00			
1184	100.00	0.00	15.56	99.91	0.07	0.204	0.00	0.00			
995.6	100.00	0.00	13.08	99.84	0.10	0.172	0.00	0.00			
837.2	100.00	0.00	11.00	99.74	0.16	0.145	0.00	0.00			
704.0	100.00	0.00	9.250	99.58	0.24	0.122	0.00	0.00			
592.0	100.00	0.00	7.778	99.34	0.38	0.102	0.00	0.00			
497.8	100.00	0.00	6.541	98.96	0.63	0.086	0.00	0.00			
418.6	100.00	0.00	5.500	98.33	1.06	0.072	0.00	0.00			
352.0	100.00	0.00	4.625	97.27	1.79	0.061	0.00	0.00			
296.0	100.00	0.00	3.889	95.48	3.26	0.051	0.00	0.00			
248.9	100.00	0.00	3.270	92.22	5.48	0.043	0.00	0.00			
209.3	100.00	0.00	2.750	86.74	9.22	0.036	0.00	0.00			
176.0	100.00	0.00	2.312	77.52	13.11	0.030	0.00	0.00			
148.0	100.00	0.00	1.945	64.41	18.06	0.026	0.00	0.00			
124.5	100.00	0.00	1.635	46.35	23.66						
104.7	100.00	0.00	1.375	22.69	22.69						
88.00	100.00	0.00	1.156	0.00	0.00						
74.00	100.00	0.00	0.972	0.00	0.00						
62.23	100.00	0.00	0.818	0.00	0.00						
52.33	100.00	0.00	0.688	0.00	0.00						
44.00	100.00	0.00	0.578	0.00	0.00						
37.00	100.00	0.00	0.486	0.00	0.00						
31.11	100.00	0.01	0.409	0.00	0.00						
26.16	99.99	0.01	0.344	0.00	0.00						
22.00	99.98	0.03	0.289	0.00	0.00						

Distribution: Number
Progression: Standard
Upper Edge: 1408
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 64
Filter: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: DefaultParticle
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN90\MTWIN.DB

Fluid: Water
Fluid Refractive Index: 1.33
Loading Factor: 0.2890
Transmission: 0.96
Above Residual: 0.00
Below Residual: 0.00

Analysis Mode: S3000
Sample Cell Id: 0188

ASVR Flow Rate: 75
Ultrasonic Power: 25 watts
Ultrasonic Time: 60 seconds

Figure I-46. Batch 4A AN102R2 post filtration precipitation solids
(NUMBER Distribution)

APPENDIX J

Experimental Data: Precipitation Test Rig Operations Data

<u>Appendix Contents</u>

Nomenclature for Data Sheets

- HX Outlet Temp TC0 (^oC), Temperature of the liquid at the outlet of the heat exchanger in the large recirculation loop
- Recir Pump Outlet Temp TC1 (^oC), Temperature of the liquid at the discharge of the pump in the large recirculation loop
- Tank Bottom Temp TC2 (^oC), Temperature of the liquid exiting the bottom of the mechanically agitated precipitation Tank
- Heater Outlet Temp TC3 (^oC), Temperature of the liquid at the outlet of the heater in the large recirculation loop
- Recir Pump Flow (gpm), Flow of liquid through the pump in the recirculation loop
- Heater Current (amps), Current on one phase of heater in the recirculation loop
- Heater Voltage (volts), Voltage applied to heater in the recirculation loop
- $NaMnO_4$ Flow (gpm), Flow of 1M $NaMnO_4$ reagent through reagent recirculation loop for mixing, or directed to precipitation tank
- $Sr(NO_3)_2$ Flow (gpm), Flow of 1M $Sr(NO_3)_2$ reagent through reagent recirculation loop for mixing, or directed to precipitation tank
- PJM Tank Level (inches), The height of liquid inside the pulsejet mixer referenced to the transition from the bottom conical portion to the cylindrical portion of the tank
- Pulse Tube Pressure (psig), pressure inside the pulse tube measured at a dedicated fitting in the top flange of the pulsejet
- Heater Outlet Temp TC8 (^oC), Temperature of the liquid at the outlet of the heater in the small recirculation loop of the pulsejet mixed precipitation tank
- Tank Bottom Temp TC10 (^oC), Temperature of the liquid exiting the bottom of the pulsejet mixed precipitation tank
- Pressure solenoid position, 0 = switched to vacuum/vent position, 1 = switched to compressed air supply

- Vacuum solenoid position, 0 = valve closed, 1 = valve opened to blower
- Vent solenoid position, 0 = valve closed, 1 = valve opened to room air
- Pressure Stop Set (inches), The PJM Tank Level at which the pressure solenoid is switched from the compressed air supply to the vacuum/vent line
- Vacuum Stop Set (inches), The PJM Tank Level at which the vacuum valve is closed and the vent valve is opened
- Total Cycle Time (sec), The length of time between the start of one pressure pulse and the start of the next pressure pulse

The first page of each data set contained in the CD follows:

PREC1_092601_0621										
DATE	TIME	HX Outlet Temp TC0 (^oC)	Recir Pump Outlet Temp TC1 (^oC)	Tank Bottom Temp TC2 (^oC)	Heater Outlet Temp TC3 (^oC)	Recir Pump Flow (gpm)	Heater Current (amps)	Heater Voltage (volts)	$NaMnO_4$ Flow (gpm)	$Sr(NO_3)_2$ Flow (gpm)
9/26/2001	6:21	20.8	20.5	21.0	20.4	-0.1	0	0	0.0	0.0
9/26/2001	6:21	20.8	20.5	21.0	20.4	-0.1	0	0	0.0	0.0
9/26/2001	6:22	26.9	33.3	33.9	25.5	9.8	0	0	0.0	0.0
9/26/2001	6:23	32.8	33.5	33.7	32.9	9.7	0	0	0.0	0.0
9/26/2001	6:24	33.1	33.5	33.6	33.2	9.7	0	0	0.0	0.0
9/26/2001	6:25	33.1	33.4	33.6	33.3	9.5	0	0	0.0	0.0
9/26/2001	6:26	33.2	33.4	33.6	33.3	9.7	0	0	0.0	0.0
9/26/2001	6:27	33.2	33.4	33.5	33.3	9.7	0	0	0.0	0.0
9/26/2001	6:28	33.2	33.4	33.5	33.4	9.7	0	0	0.0	0.0
9/26/2001	6:29	33.2	33.4	33.5	33.4	9.6	0	0	0.0	0.0
9/26/2001	6:30	33.2	33.3	33.5	33.4	9.7	0	0	0.0	0.0
9/26/2001	6:31	33.2	33.3	33.5	33.4	9.7	0	0	0.0	0.0
9/26/2001	6:32	33.2	33.3	33.5	33.4	9.6	0	0	0.0	0.0
9/26/2001	6:33	33.2	33.3	33.4	33.4	9.6	0	0	0.0	0.0
9/26/2001	6:34	33.2	33.3	33.4	34.4	9.8	17	194	0.0	-1.3
9/26/2001	6:35	33.3	33.4	33.6	35.9	9.6	20	194	0.0	-1.2
9/26/2001	6:36	33.4	33.5	33.7	36.1	9.6	19	195	0.0	-1.3
9/26/2001	6:37	33.5	33.6	33.7	36.2	9.6	20	194	0.0	-1.3
9/26/2001	6:38	33.6	33.7	33.8	36.3	9.7	19	194	0.0	-1.2
9/26/2001	6:39	33.6	33.7	33.9	36.4	9.7	20	194	0.0	-1.2
9/26/2001	6:40	33.7	33.8	34.0	36.4	9.7	20	194	0.0	-1.2
9/26/2001	6:41	33.8	33.9	34.1	36.5	9.5	20	194	0.0	-1.3
9/26/2001	6:42	25.0	24.7	25.1	25.0	-0.1	20	194	0.0	-1.3
9/26/2001	6:43	24.8	24.8	25.2	25.0	9.7	0	0	0.0	0.0
9/26/2001	6:44	24.9	24.9	25.3	25.1	9.6	0	0	0.0	0.0
9/26/2001	6:45	24.9	24.9	25.3	25.1	-0.1	0	0	0.0	0.0
9/26/2001	6:46	24.9	24.9	25.3	25.1	9.7	0	0	0.0	0.0
9/26/2001	6:47	24.9	24.9	25.3	25.1	9.6	0	0	0.0	0.0
9/26/2001	6:48	34.1	34.1	34.2	34.2	-0.1	0	0	0.0	0.0
9/26/2001	6:49	33.8	33.9	34.3	34.0	1.4	0	0	0.0	0.0
9/26/2001	6:50	34.1	34.2	34.3	34.2	9.7	0	0	0.0	0.0
9/26/2001	6:51	34.1	34.2	34.3	36.6	9.6	19	194	0.0	-1.2
9/26/2001	6:52	34.2	34.3	34.5	37.0	9.7	19	194	0.0	-1.3
9/26/2001	6:53	34.4	34.5	34.6	37.0	9.6	19	194	0.0	-1.3
9/26/2001	6:54	34.4	34.5	34.7	37.1	9.6	20	194	0.0	-1.4
9/26/2001	6:55	34.5	34.6	34.8	37.2	9.8	19	194	0.0	-1.4
9/26/2001	6:56	34.6	34.7	34.8	37.3	9.6	20	194	0.0	-1.3
9/26/2001	6:57	34.8	34.8	34.9	37.5	9.6	20	194	0.0	-1.4
9/26/2001	6:58	34.9	34.9	35.0	37.5	9.6	20	194	0.0	-1.3
9/26/2001	6:59	35.0	35.0	35.2	37.7	9.6	19	194	0.0	-1.3
9/26/2001	7:00	35.1	35.1	35.2	37.7	9.6	19	194	0.0	-1.3
9/26/2001	7:01	35.2	35.3	35.4	37.7	9.6	19	194	0.0	-1.3
9/26/2001	7:02	35.3	35.4	35.5	38.1	9.7	20	194	0.0	-1.3
9/26/2001	7:03	35.4	35.5	35.6	38.1	9.6	19	194	0.0	-1.3
9/26/2001	7:04	35.5	35.6	35.7	38.2	9.6	20	194	0.0	-1.3
9/26/2001	7:05	35.7	35.7	35.8	38.4	9.7	19	194	0.0	-1.3
9/26/2001	7:06	35.8	35.8	35.9	38.5	9.6	19	194	0.0	-1.3
9/26/2001	7:07	35.9	36.0	36.1	38.6	9.8	19	194	0.0	-1.3

PREC2_102301_0623										
DATE	TIME	HX Outlet Temp TC0 (^oC)	Recir Pump Outlet Temp TC1 (^oC)	Tank Bottom Temp TC2 (^oC)	Heater Outlet Temp TC3 (^oC)	Recir Pump Flow (gpm)	Heater Current (amps)	Heater Voltage (volts)	$NaMnO_4$ Flow (gpm)	$Sr(NO_3)_2$ Flow (gpm)
10/23/2001	6:24	20.6	20.6	20.8	20.6	-0.1	0	0	0.0	0.0
10/23/2001	6:25	20.6	20.6	20.8	20.6	-0.1	0	0	0.0	0.0
10/23/2001	6:26	20.6	20.6	20.8	20.6	-0.1	0	0	0.0	0.0
10/23/2001	6:27	20.6	20.6	20.8	20.7	-0.1	0	0	0.0	0.0
10/23/2001	6:28	20.6	20.6	20.9	20.6	-0.1	65	79	0.0	0.0
10/23/2001	6:29	20.6	20.6	20.9	20.7	-0.1	65	79	0.0	0.0
10/23/2001	6:30	20.6	20.6	20.9	20.7	-0.1	65	79	0.1	0.0
10/23/2001	6:31	20.6	20.6	20.9	20.7	-0.1	65	79	0.0	0.0
10/23/2001	6:32	20.6	20.6	20.9	20.7	-0.1	65	79	0.0	0.0
10/23/2001	6:33	20.6	20.6	20.9	20.7	-0.1	65	79	0.0	0.0
10/23/2001	6:34	20.6	20.6	20.9	20.7	-0.1	65	79	0.2	0.0
10/23/2001	6:35	20.6	20.6	20.9	20.7	-0.1	65	79	0.2	0.0
10/23/2001	6:36	20.6	20.6	20.9	20.7	-0.1	65	79	0.0	0.0
10/23/2001	6:37	20.6	20.6	20.9	20.7	-0.1	65	79	0.0	0.0
10/23/2001	6:38	20.6	20.6	20.8	20.7	-0.1	65	79	0.0	0.0
10/23/2001	6:39	21.6	21.6	21.7	21.6	9.6	65	79	0.0	0.0
10/23/2001	6:40	21.6	21.6	21.7	21.6	9.6	65	79	0.0	0.0
10/23/2001	6:41	21.7	21.6	21.7	21.7	9.7	65	79	0.0	0.0
10/23/2001	6:42	21.7	21.7	21.7	21.7	9.6	65	79	0.0	0.0
10/23/2001	6:43	20.9	21.7	21.7	20.9	9.6	65	79	0.1	0.0
10/23/2001	6:44	21.3	21.6	21.7	21.2	9.6	65	79	0.3	0.0
10/23/2001	6:45	20.6	21.6	21.7	20.5	9.7	65	79	0.2	0.0
10/23/2001	6:46	21.1	21.6	21.6	21.1	9.6	65	79	0.2	0.0
10/23/2001	6:47	20.6	21.6	21.6	20.6	9.7	65	79	0.0	0.0
10/23/2001	6:48	21.1	21.5	21.6	21.0	9.6	65	79	0.0	0.0
10/23/2001	6:49	20.6	21.5	21.6	20.6	9.7	65	79	0.0	0.0
10/23/2001	6:50	21.0	21.5	21.5	21.0	9.6	65	79	0.0	0.0
10/23/2001	6:51	20.5	21.5	21.5	20.6	9.6	65	79	0.1	0.0
10/23/2001	6:52	21.0	21.4	21.5	20.9	9.6	65	79	0.0	0.0
10/23/2001	6:53	20.9	21.4	21.5	20.9	9.6	65	79	0.0	0.0
10/23/2001	6:54	20.8	21.4	21.4	20.7	9.6	65	79	0.0	0.0
10/23/2001	6:55	21.0	21.4	21.4	21.0	9.7	65	79	0.0	0.0
10/23/2001	6:56	20.7	21.3	21.4	20.6	9.6	65	79	0.0	0.0
10/23/2001	6:57	21.0	21.3	21.4	20.9	9.6	65	79	0.0	0.0
10/23/2001	6:58	20.5	21.3	21.4	20.4	9.7	65	79	0.0	0.0
10/23/2001	6:59	20.9	21.3	21.3	20.9	9.7	65	79	0.0	0.0
10/23/2001	7:00	20.3	21.3	21.3	20.3	9.7	65	79	0.1	0.0
10/23/2001	7:01	21.1	21.5	21.5	21.0	9.6	65	79	5.0	0.0
10/23/2001	7:02	21.0	21.7	21.7	20.9	9.6	65	79	5.0	0.0
10/23/2001	7:03	21.4	21.8	21.8	21.1	9.6	65	79	5.0	0.0
10/23/2001	7:04	21.6	21.8	21.8	21.3	9.7	65	79	5.0	0.0
10/23/2001	7:05	21.3	21.8	21.8	20.8	9.6	65	79	5.0	0.0
10/23/2001	7:06	21.6	21.8	21.7	21.2	9.6	65	79	5.0	0.0
10/23/2001	7:07	21.0	21.8	21.7	20.6	9.5	65	79	5.0	0.0
10/23/2001	7:08	21.5	21.7	21.7	21.1	9.6	65	79	5.0	0.0

PREC2_102401_0627

DATE	TIME	HX Outlet Temp TC0 (^oC)	Recir Pump Outlet Temp TC1 (^oC)	Tank Bottom Temp TC2 (^oC)	Heater Outlet Temp TC3 (^oC)	Recir Pump Flow (gpm)	Heater Current (amps)	Heater Voltage (volts)	$NaMnO_4$ Flow (gpm)	$Sr(NO_3)_2$ Flow (gpm)
10/24/2001	6:27	18.8	18.9	18.9	18.7	9.6	99	79	0.0	0.0
10/24/2001	6:28	18.8	18.9	18.9	18.7	9.6	99	79	0.0	0.0
10/24/2001	6:29	18.8	18.9	18.9	18.6	9.8	23	79	0.0	0.0
10/24/2001	6:30	18.8	18.9	18.9	18.6	9.7	29	79	0.0	0.0
10/24/2001	6:31	18.8	18.9	18.9	18.7	9.6	35	79	0.0	0.0
10/24/2001	6:32	18.8	19.0	18.9	18.6	9.6	21	79	0.0	0.0
10/24/2001	6:33	18.8	19.0	18.9	18.7	9.7	97	79	0.0	0.0
10/24/2001	6:34	18.8	19.0	18.9	18.7	9.7	23	79	0.0	0.0
10/24/2001	6:35	18.9	19.0	18.9	18.7	9.6	26	79	0.0	0.0
10/24/2001	6:36	18.8	19.0	19.0	18.7	9.6	40	79	0.0	0.0
10/24/2001	6:37	18.9	19.0	19.0	18.7	9.6	29	79	0.0	0.0
10/24/2001	6:38	18.8	19.0	19.0	18.7	9.7	26	79	0.0	0.0
10/24/2001	6:39	18.9	19.0	19.0	18.7	9.7	50	79	0.0	0.0
10/24/2001	6:40	18.8	19.0	19.0	18.7	9.6	25	79	0.0	0.0
10/24/2001	6:41	18.8	19.0	19.0	18.7	9.6	21	79	0.0	0.0
10/24/2001	6:42	18.9	19.0	19.0	18.7	9.6	37	79	0.0	0.0
10/24/2001	6:43	18.8	19.0	19.0	18.7	9.6	46	79	0.0	0.0
10/24/2001	6:44	18.9	19.0	19.0	18.7	9.7	28	79	0.0	0.0
10/24/2001	6:45	18.9	19.0	19.0	18.7	9.6	20	79	0.0	0.0
10/24/2001	6:46	18.9	19.0	19.0	18.8	9.7	20	79	0.0	0.0
10/24/2001	6:47	18.9	19.0	19.0	18.7	9.6	21	79	0.0	0.0
10/24/2001	6:48	18.9	19.1	19.0	18.8	9.6	21	79	0.0	0.0
10/24/2001	6:49	18.9	19.1	19.0	18.7	9.5	21	79	0.0	0.0
10/24/2001	6:50	18.9	19.1	19.0	18.8	9.7	37	79	0.0	0.0
10/24/2001	6:51	18.9	19.1	19.0	18.7	9.6	21	79	0.0	0.0
10/24/2001	6:52	18.9	19.1	19.0	18.8	9.6	21	79	0.0	0.0
10/24/2001	6:53	18.9	19.1	19.0	18.8	9.7	21	79	0.0	0.0
10/24/2001	6:54	18.9	19.1	19.1	18.8	9.6	21	79	0.0	0.0
10/24/2001	6:55	18.9	19.1	19.0	18.8	9.7	21	79	0.0	0.0
10/24/2001	6:56	18.9	19.1	19.0	18.8	9.7	21	79	0.0	0.0
10/24/2001	6:57	19.0	19.1	19.1	18.8	9.6	21	79	0.0	0.0
10/24/2001	6:58	18.9	19.1	19.1	18.8	9.6	21	79	0.0	0.0
10/24/2001	6:59	19.0	19.1	19.1	18.8	9.6	21	79	0.0	0.0
10/24/2001	7:00	18.9	19.1	19.1	18.8	9.6	21	79	0.0	0.0
10/24/2001	7:01	19.0	19.1	19.1	18.8	9.6	21	79	0.0	0.0
10/24/2001	7:02	18.9	19.1	19.1	18.8	9.7	21	79	0.0	0.0
10/24/2001	7:03	19.0	19.1	19.1	18.8	9.6	21	79	0.0	0.0
10/24/2001	7:04	18.9	19.1	19.1	18.8	9.6	21	79	0.0	0.0
10/24/2001	7:05	19.0	19.1	19.1	18.8	9.7	21	79	0.0	0.0
10/24/2001	7:06	19.0	19.1	19.1	18.8	9.7	21	79	0.0	0.0
10/24/2001	7:07	19.0	19.1	19.1	18.8	9.7	21	79	0.0	0.0
10/24/2001	7:08	19.0	19.1	19.1	18.9	9.7	21	79	0.0	0.0
10/24/2001	7:09	19.0	19.2	19.1	18.8	9.5	21	79	0.0	0.0
10/24/2001	7:10	19.0	19.2	19.1	18.9	9.7	21	79	0.0	0.0
10/24/2001	7:11	19.0	19.2	19.2	18.8	9.6	21	79	0.0	0.0

PREC3C_100102_0930										
DATE	TIME	HX Outlet Temp TC0 (^oC)	Recir Pump Outlet Temp TC1 (^oC)	Tank Bottom Temp TC2 (^oC)	Heater Outlet Temp TC3 (^oC)	Recir Pump Flow (gpm)	Heater Current	Heater Voltage	$NaMnO_4$ Flow (gpm)	$Sr(NO_3)_2$ Flow (gpm)
10/1/2002	9:26	21.0	21.0	21.0	21.0	-0.1	0	0	0.0	0.0
10/1/2002	9:26	21.0	21.0	21.0	21.0	-0.1	0	0	0.0	0.0
10/1/2002	9:27	21.0	21.1	21.0	21.0	-0.1	0	0	0.0	0.0
10/1/2002	9:28	22.7	22.8	22.6	22.5	9.7	0	0	0.0	0.0
10/1/2002	9:29	22.8	22.8	22.6	22.7	9.6	0	0	0.0	0.0
10/1/2002	9:30	22.9	22.8	22.7	22.8	9.6	0	0	0.0	0.0
10/1/2002	9:31	22.9	22.8	22.7	22.8	9.6	0	0	0.0	0.0
10/1/2002	9:32	22.9	22.9	22.7	22.8	9.6	0	0	0.0	0.0
10/1/2002	9:33	22.9	22.9	22.7	22.8	9.6	0	0	0.0	0.0
10/1/2002	9:34	23.0	22.9	22.7	22.8	9.6	0	0	0.0	0.0
10/1/2002	9:35	23.0	22.9	22.7	22.9	9.6	0	0	0.0	0.0
10/1/2002	9:36	23.0	22.9	22.7	22.9	9.7	0	0	0.0	0.0
10/1/2002	9:37	23.0	23.0	22.8	22.9	9.6	0	0	0.0	0.0
10/1/2002	9:38	23.0	23.0	22.8	22.9	9.7	0	0	0.0	0.0
10/1/2002	9:39	23.0	23.0	22.8	22.9	9.6	0	0	0.0	0.0
10/1/2002	9:40	23.1	23.0	22.8	23.0	9.6	0	0	0.0	0.0
10/1/2002	9:41	23.1	23.0	22.8	23.0	9.6	0	0	0.0	0.0
10/1/2002	9:42	23.1	23.0	22.9	23.0	9.5	0	0	0.0	0.0
10/1/2002	9:43	23.1	23.1	22.9	23.0	9.6	0	0	0.0	0.0
10/1/2002	9:44	23.1	23.1	22.9	23.0	9.6	0	0	0.0	0.0
10/1/2002	9:45	23.1	23.1	22.9	23.0	9.6	0	0	0.0	0.0
10/1/2002	9:46	23.2	23.1	22.9	23.1	9.6	0	0	0.0	0.0
10/1/2002	9:47	23.2	23.1	22.9	23.1	9.6	0	0	0.0	0.0
10/1/2002	9:48	23.2	23.1	22.9	23.1	9.6	0	0	0.0	0.0
10/1/2002	9:49	23.2	23.1	23.0	23.1	9.7	0	0	0.0	0.0
10/1/2002	9:50	23.2	23.1	23.0	23.1	9.5	0	0	0.0	0.0
10/1/2002	9:51	23.2	23.2	23.0	23.1	9.6	0	0	0.0	0.0
10/1/2002	9:52	23.2	23.2	23.0	23.1	9.6	0	0	0.0	0.0
10/1/2002	9:53	23.3	23.2	23.0	23.2	9.6	0	0	0.0	0.0
10/1/2002	9:54	23.3	23.2	23.0	23.2	9.6	0	0	0.0	0.0
10/1/2002	9:55	23.3	23.2	23.0	23.2	9.6	0	0	0.0	0.0
10/1/2002	9:56	23.3	23.3	23.0	23.2	9.6	0	0	0.0	0.0
10/1/2002	9:57	23.3	23.3	23.1	23.2	9.6	0	0	0.0	0.0
10/1/2002	9:58	23.3	23.3	23.1	23.2	9.7	0	0	0.0	0.0
10/1/2002	9:59	23.4	23.3	23.1	23.3	9.6	0	0	0.0	0.0
10/1/2002	10:00	23.4	23.3	23.1	23.3	9.6	0	0	0.0	0.0
10/1/2002	10:01	23.4	23.3	23.1	23.3	9.6	0	0	0.0	0.0
10/1/2002	10:02	23.4	23.3	23.1	23.3	9.6	0	0	0.0	0.0
10/1/2002	10:03	23.4	23.4	23.2	23.3	9.6	0	0	0.0	0.0
10/1/2002	10:04	23.4	23.4	23.2	23.3	9.6	0	0	0.0	0.0
10/1/2002	10:05	23.5	23.4	23.2	23.4	9.5	0	0	0.0	0.0
10/1/2002	10:06	23.5	23.4	23.2	23.4	9.6	0	0	0.0	0.0
10/1/2002	10:07	23.5	23.4	23.2	23.4	9.6	0	0	0.0	0.0
10/1/2002	10:08	23.5	23.5	23.2	23.4	9.7	0	0	0.0	0.0
10/1/2002	10:09	23.5	23.5	23.3	23.4	9.6	0	0	0.0	0.0

PREC3B_102102_0644										
DATE	TIME	HX Outlet Temp TC0 (^oC)	Recir Pump Outlet Temp TC1 (^oC)	Tank Bottom Temp TC2 (^oC)	Heater Outlet Temp TC3 (^oC)	Recir Pump Flow (gpm)	Heater Current	Heater Voltage	$NaMnO_4$ Flow (gpm)	$Sr(NO_3)_2$ Flow (gpm)
10/21/2002	6:43	22.5	22.2	22.6	22.1	-0.1	0	0	0.0	0.0
10/21/2002	6:44	22.5	22.2	22.6	22.1	-0.1	0	0	0.0	0.0
10/21/2002	6:45	22.5	22.2	22.6	22.1	-0.1	0	0	0.0	0.0
10/21/2002	6:46	23.2	23.1	23.0	23.0	9.6	0	0	0.0	0.0
10/21/2002	6:47	23.3	23.2	23.1	25.6	9.6	19	198	0.0	0.0
10/21/2002	6:48	23.4	23.3	23.1	25.7	9.7	21	198	0.0	0.0
10/21/2002	6:49	23.4	23.4	23.2	25.8	9.6	20	198	0.0	0.0
10/21/2002	6:50	23.5	23.4	23.3	25.8	9.6	20	198	0.0	0.0
10/21/2002	6:51	23.6	23.5	23.3	25.9	9.6	20	198	0.0	0.0
10/21/2002	6:52	23.7	23.6	23.4	26.0	9.6	20	198	0.0	0.0
10/21/2002	6:53	23.7	23.7	23.5	26.1	9.6	20	198	0.0	0.0
10/21/2002	6:54	23.8	23.8	23.6	26.2	9.6	20	198	0.0	0.0
10/21/2002	6:55	23.9	23.9	23.7	26.3	9.6	20	198	0.0	0.0
10/21/2002	6:56	24.0	24.0	23.8	26.4	9.6	20	198	0.0	0.0
10/21/2002	6:57	24.2	24.1	23.9	26.5	9.5	20	198	0.0	0.0
10/21/2002	6:58	24.2	24.2	24.0	26.6	9.5	20	198	0.0	0.0
10/21/2002	6:59	24.4	24.3	24.1	26.6	9.5	20	198	0.0	0.0
10/21/2002	7:00	24.5	24.4	24.2	26.8	9.6	20	198	0.0	0.0
10/21/2002	7:01	24.6	24.5	24.3	26.9	9.6	20	198	0.0	0.0
10/21/2002	7:02	24.7	24.6	24.4	27.0	9.6	20	198	0.0	0.0
10/21/2002	7:03	24.8	24.7	24.5	27.1	9.6	20	198	0.0	0.0
10/21/2002	7:04	24.9	24.8	24.7	27.2	9.6	20	198	0.0	0.0
10/21/2002	7:05	25.0	24.9	24.8	27.4	9.7	20	198	0.0	0.0
10/21/2002	7:06	25.1	25.0	24.9	27.5	9.5	20	198	0.0	0.0
10/21/2002	7:07	25.2	25.2	25.0	27.6	9.6	20	198	0.0	0.0
10/21/2002	7:08	25.3	25.3	25.1	27.6	9.6	20	198	0.0	0.0
10/21/2002	7:09	25.4	25.4	25.2	27.8	9.6	20	198	0.0	0.0
10/21/2002	7:10	25.5	25.5	25.3	27.9	9.6	20	198	0.0	0.0
10/21/2002	7:11	25.7	25.6	25.4	27.9	9.6	20	198	0.0	0.0
10/21/2002	7:12	25.7	25.7	25.5	28.1	9.6	20	198	0.0	0.0
10/21/2002	7:13	25.9	25.8	25.6	28.2	9.6	20	198	0.0	0.0
10/21/2002	7:14	26.0	25.9	25.7	28.3	9.6	20	198	0.0	0.0
10/21/2002	7:15	26.1	26.0	25.8	28.4	9.6	20	198	0.0	0.0
10/21/2002	7:16	26.2	26.1	26.0	28.5	9.6	20	198	0.0	0.0
10/21/2002	7:17	26.3	26.2	26.1	28.6	9.7	20	198	0.0	0.0
10/21/2002	7:18	26.4	26.3	26.2	28.8	9.6	20	198	0.0	0.0
10/21/2002	7:19	26.5	26.4	26.3	28.8	9.6	20	198	0.0	0.0
10/21/2002	7:20	26.6	26.5	26.4	28.9	9.6	20	198	0.0	0.0
10/21/2002	7:21	26.7	26.6	26.5	29.0	9.6	20	198	0.0	0.0
10/21/2002	7:22	26.8	26.8	26.6	29.2	9.6	20	198	0.0	0.0
10/21/2002	7:23	26.9	26.9	26.7	29.2	9.6	20	198	0.0	0.0
10/21/2002	7:24	27.0	27.0	26.8	29.3	9.5	20	198	0.0	0.0
10/21/2002	7:25	27.1	27.1	26.9	29.5	9.6	20	198	0.0	0.0
10/21/2002	7:26	27.2	27.2	27.0	29.6	9.6	20	198	0.0	0.0
10/21/2002	7:27	27.4	27.3	27.1	29.7	9.5	20	198	0.0	0.0

PREC3A_110602_0630										
DATE	TIME	HX Outlet Temp TC0 (^oC)	Recirc Pump Outlet Temp TC1 (^oC)	Tank Bottom Temp TC2 (^oC)	Heater Outlet Temp TC3 (^oC)	Recirc Pump Flow (gpm)	Heater Current	Heater Voltage	$NaMnO_4$ Flow (gpm)	$Sr(NO_3)_2$ Flow (gpm)
11/6/2002	6:28	22.4	22.5	22.6	22.2	-0.1	0	0	0.0	0.0
11/6/2002	6:29	22.4	22.5	22.6	22.2	-0.1	0	0	0.0	0.0
11/6/2002	6:30	22.4	22.5	22.6	22.2	-0.1	0	0	0.0	0.0
11/6/2002	6:31	22.4	21.8	21.0	22.2	-0.1	0	0	0.0	0.0
11/6/2002	6:32	21.5	21.3	21.1	21.4	9.6	0	0	0.0	0.0
11/6/2002	6:33	21.5	21.4	21.1	21.4	9.5	0	0	0.0	0.0
11/6/2002	6:34	21.5	21.4	21.1	21.4	9.6	0	0	0.0	0.0
11/6/2002	6:35	21.5	21.4	21.2	21.4	9.5	0	0	0.0	0.0
11/6/2002	6:36	21.5	21.4	21.2	21.4	9.5	0	0	0.0	0.0
11/6/2002	6:37	21.6	21.5	21.2	21.4	9.6	0	0	0.0	0.0
11/6/2002	6:38	21.6	21.5	21.2	21.5	9.6	0	0	0.0	0.0
11/6/2002	6:39	21.6	21.5	21.3	21.5	9.5	0	0	0.0	0.0
11/6/2002	6:40	21.7	21.6	21.3	21.5	9.5	0	0	0.0	0.0
11/6/2002	6:41	21.7	21.6	21.3	21.5	9.6	0	0	0.0	0.0
11/6/2002	6:42	21.7	21.6	21.3	21.6	9.5	0	0	0.0	0.0
11/6/2002	6:43	21.7	21.7	21.4	21.6	9.6	0	0	0.0	0.0
11/6/2002	6:44	21.8	21.7	21.4	21.6	9.6	0	0	0.0	0.0
11/6/2002	6:45	21.8	21.7	21.4	21.6	9.5	0	0	0.0	0.0
11/6/2002	6:46	21.8	21.7	21.4	21.7	9.6	0	0	0.0	0.0
11/6/2002	6:47	21.8	21.7	21.4	21.7	9.5	0	0	0.0	0.0
11/6/2002	6:48	21.8	21.8	21.5	21.7	9.6	0	0	0.0	0.0
11/6/2002	6:49	21.9	21.8	21.5	21.7	9.6	0	0	0.0	0.0
11/6/2002	6:50	21.9	21.8	21.5	21.8	9.6	0	0	0.0	0.0
11/6/2002	6:51	21.9	21.8	21.5	21.8	9.6	0	0	0.0	0.0
11/6/2002	6:52	21.9	21.9	21.6	21.8	9.6	0	0	0.0	0.0
11/6/2002	6:53	22.0	21.9	21.6	22.3	9.6	90	138	0.0	0.0
11/6/2002	6:54	22.0	21.9	21.6	22.5	9.6	106	138	0.0	0.0
11/6/2002	6:55	22.0	21.9	21.7	22.5	9.5	115	140	0.0	0.0
11/6/2002	6:56	22.1	22.0	21.7	22.6	9.6	86	141	0.0	0.0
11/6/2002	6:57	22.1	22.0	21.7	22.7	9.6	118	143	0.0	0.0
11/6/2002	6:58	22.1	22.1	21.8	22.8	9.6	115	143	0.0	0.0
11/6/2002	6:59	22.2	22.1	21.8	22.8	9.6	103	144	0.0	0.0
11/6/2002	7:00	22.2	22.1	21.9	22.9	9.6	101	145	0.0	0.0
11/6/2002	7:01	22.3	22.2	21.9	23.0	9.6	82	144	0.0	0.0
11/6/2002	7:02	22.3	22.2	22.0	23.1	9.6	117	149	0.0	0.0
11/6/2002	7:03	22.4	22.3	22.0	23.1	9.5	114	148	0.0	0.0
11/6/2002	7:04	22.4	22.3	22.1	23.2	9.5	114	151	0.0	0.0
11/6/2002	7:05	22.5	22.4	22.1	23.3	9.6	94	151	0.0	0.0
11/6/2002	7:06	22.5	22.5	22.2	23.4	9.6	114	153	0.0	0.0
11/6/2002	7:07	22.6	22.5	22.2	23.4	9.6	130	154	0.0	0.0
11/6/2002	7:08	22.7	22.6	22.3	23.5	9.7	129	154	0.0	0.0
11/6/2002	7:09	22.7	22.6	22.4	23.6	9.5	116	154	0.0	0.0
11/6/2002	7:10	22.8	22.7	22.4	23.6	9.6	96	155	0.0	0.0
11/6/2002	7:11	22.8	22.7	22.5	23.7	9.6	105	156	0.5	0.0
11/6/2002	7:12	22.8	22.8	22.5	23.8	9.7	124	157	0.4	0.0

PJM4A_031003_0730												
DATE	TIME	PJM Tank Level (inches)	Pulse Tube Pressure (psig)	Heater Outlet Temp TC8 (°C)	Tank Bottom Temp TC10 (°C)	Recirc Pump Flow (gpm)	Pressure solenoid position	Vacuum solenoid position	Vent solenoid position	Pressure Stop Set (inches)	Vacuum Stop Set (inches)	Total Cycle Time (sec)
3/10/2003	7:28:41	28.45	0.033	27.3	21.8	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:18	28.45	0.033	27.3	21.8	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:19	28.46	0.033	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:21	28.46	0.034	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:22	28.46	0.033	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:23	28.46	0.034	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:24	28.46	0.034	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:25	28.46	0.034	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:26	28.46	0.034	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:27	28.46	0.033	27.4	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:28	28.46	0.034	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:29	28.46	0.034	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:30	28.46	0.033	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:31	28.46	0.033	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:32	28.46	0.033	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:33	28.46	0.033	27.4	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:34	28.46	0.034	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:35	28.46	0.033	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:36	28.46	0.033	27.4	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:37	28.46	0.034	27.4	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:38	28.46	0.034	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:39	28.46	0.033	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:40	28.46	0.034	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:41	28.46	0.034	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:42	28.46	0.034	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:43	28.46	0.033	27.4	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:44	28.46	0.034	27.4	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:45	28.46	0.033	27.4	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:46	28.46	0.034	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:47	28.46	0.034	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:48	28.46	0.034	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:49	28.46	0.034	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:50	28.46	0.033	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:51	28.46	0.034	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:52	28.46	0.034	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:53	28.46	0.033	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:54	28.46	0.034	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:55	28.46	0.034	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:56	28.46	0.033	27.5	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:57	28.46	0.033	27.4	21.9	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:58	28.46	0.034	27.5	22.0	1.6	0	0	0	22.75	27	77
3/10/2003	7:30:59	28.46	0.034	27.5	22.0	1.6	0	0	0	22.75	27	77
3/10/2003	7:31:00	28.46	0.034	27.5	22.0	1.6	0	0	0	22.75	27	77
3/10/2003	7:31:01	28.46	0.034	27.5	22.0	1.6	0	0	0	22.75	27	77
3/10/2003	7:31:02	28.46	0.033	27.4	22.0	1.6	0	0	0	22.75	27	77
3/10/2003	7:31:03	28.46	0.034	27.5	22.0	1.6	0	0	0	22.75	27	77

PJM4A_031103_0616											
DATE	TIME	PJM Tank Level (inches)	Pulse Tube Pressure (psig)	Heater Outlet Temp TC8 (^oC)	Tank Bottom Temp TC10 (^oC)	Recirc Pump Flow (gpm)	Pressure solenoid position	Vacuum solenoid position	Vent solenoid position	Pressure Stop Set (inches)	Vacuum Stop Set (inches)
3/11/2003	6:16:23	30.39	0.034	51.3	51.3	1.6	0	0	1	21.5	27
3/11/2003	6:17:54	30.34	0.034	51.4	51.2	1.6	0	0	1	21.5	27
3/11/2003	6:22:54	30.46	0.034	60.6	50.7	0.5	0	0	1	21.5	27
3/11/2003	6:26:12	29.96	0.034	61.5	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:13	29.95	0.034	61.5	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:14	29.93	0.034	61.5	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:15	29.93	0.034	61.5	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:16	29.93	0.034	61.5	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:17	29.92	0.034	61.5	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:18	29.91	0.034	61.5	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:19	29.90	0.034	61.6	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:20	29.89	0.034	61.6	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:21	29.88	0.034	61.6	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:22	29.86	0.034	61.7	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:23	29.85	0.034	61.7	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:24	29.85	0.034	61.7	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:25	29.85	0.034	61.7	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:26	29.84	0.034	61.8	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:27	29.82	0.034	61.8	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:28	29.81	0.034	61.8	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:29	29.81	0.034	61.8	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:30	29.81	0.034	61.8	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:31	29.79	0.034	61.8	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:32	29.79	0.034	61.8	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:33	29.79	0.034	61.8	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:34	29.77	0.034	61.8	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:35	29.76	0.034	61.8	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:36	29.75	0.035	61.8	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:37	29.75	0.034	61.8	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:38	29.74	0.034	61.8	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:39	29.74	0.035	61.8	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:40	29.73	0.034	61.7	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:41	29.72	0.034	61.8	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:42	29.71	0.034	61.8	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:43	29.71	0.034	61.8	51.8	0.5	0	0	1	22.5	27
3/11/2003	6:26:44	29.69	0.034	61.8	51.7	0.5	0	0	1	22.5	27
3/11/2003	6:26:45	29.69	0.034	61.8	51.7	0.5	0	0	1	22.5	27
3/11/2003	6:26:46	29.69	0.035	61.9	51.7	0.5	0	0	1	22.5	27
3/11/2003	6:26:47	29.61	6.653	61.9	51.8	0.5	1	0	0	22.5	27
3/11/2003	6:26:48	20.25	11.109	61.9	51.8	0.5	0	1	0	22.5	27
3/11/2003	6:26:49	10.10	1.88	61.8	51.8	0.5	0	1	0	22.5	27
3/11/2003	6:26:50	21.98	-0.021	61.8	51.8	0.5	0	1	0	22.5	27
3/11/2003	6:26:51	23.05	-0.763	61.8	51.8	0.5	0	1	0	22.5	27
3/11/2003	6:26:52	23.58	-1.192	61.8	51.8	0.5	0	1	0	22.5	27
3/11/2003	6:26:53	25.76	-1.403	61.8	51.8	0.5	0	1	0	22.5	27
3/11/2003	6:26:54	28.22	-1.323	61.7	51.8	0.5	0	0	1	22.5	27

PJM4A_031103_1030												
DATE	TIME	PJM Tank Level (inches)	Pulse Tube Pressure (psig)	Heater Outlet Temp TC8 (^oC)	Tank Bottom Temp TC10 (^oC)	Recirc Pump Flow (gpm)	Pressure solenoid position	Vacuum solenoid position	Vent solenoid position	Pressure Stop Set (inches)	Vacuum Stop Set (inches)	Total Cycle Time (sec)
3/11/2003	10:30:14	35.92	0.0	53.0	53.4	0.5	0	0	1	27	27	77
3/11/2003	10:30:36	35.92	0.0	53.0	53.4	0.5	0	0	1	27	27	77
3/11/2003	10:30:37	36.27	0.0	53.0	53.4	0.5	0	0	1	27	27	77
3/11/2003	10:30:38	36.27	0.0	53.0	53.4	0.5	0	0	1	27	27	77
3/11/2003	10:30:39	36.27	0.0	53.0	53.4	0.5	0	0	1	27	27	77
3/11/2003	13:56:56	36.06	0.0	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:06	36.06	0.0	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:07	36.01	0.0	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:08	36.00	0.1	29.0	28.7	1.6	1	0	0	27	27	77
3/11/2003	13:57:09	34.04	11.0	29.0	28.7	1.6	1	0	0	27	27	77
3/11/2003	13:57:10	17.70	6.9	29.0	28.7	1.6	0	1	0	27	27	77
3/11/2003	13:57:11	11.55	0.8	29.0	28.7	1.6	0	1	0	27	27	77
3/11/2003	13:57:12	24.05	-0.2	29.0	28.7	1.6	0	1	0	27	27	77
3/11/2003	13:57:13	23.99	0.1	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:14	22.56	0.5	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:15	23.60	0.5	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:16	24.87	0.4	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:17	26.02	0.4	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:18	27.06	0.3	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:19	27.97	0.3	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:20	28.89	0.3	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:21	29.73	0.2	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:22	30.49	0.2	28.9	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:23	31.20	0.2	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:24	31.89	0.2	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:25	32.54	0.1	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:26	33.17	0.1	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:27	33.79	0.1	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:28	34.35	0.1	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:29	34.86	0.1	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:30	35.31	0.1	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:31	35.71	0.1	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:32	36.02	0.0	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:33	36.23	0.0	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:34	36.33	0.0	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:35	36.31	0.0	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:36	36.25	0.0	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:37	36.24	0.0	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:38	36.27	0.0	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:39	36.26	0.0	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:40	36.26	0.0	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:41	36.25	0.0	28.9	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:42	36.25	0.0	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:43	36.25	0.0	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:44	36.27	0.0	29.0	28.7	1.6	0	0	1	27	27	77
3/11/2003	13:57:45	36.29	0.0	29.0	28.7	1.6	0	0	1	27	27	77

PJM4A_031203_0251												
DATE	TIME	PJM Tank Level (inches)	Pulse Tube Pressure (psig)	Heater Outlet Temp TC8 (°C)	Tank Bottom Temp TC10 (°C)	Recirc Pump Flow (gpm)	Pressure solenoid position	Vacuum solenoid position	Vent solenoid position	Pressure Stop Set (inches)	Vacuum Stop Set (inches)	Total Cycle Time (sec)
3/12/2003	2:50:00	34.19	0.0	32.4	33.0	0.5	0	0	0	10	28	77
3/12/2003	2:51:15	34.19	0.0	32.4	33.0	0.5	0	0	0	10	28	77
3/12/2003	2:51:16	34.08	0.0	32.4	32.9	0.5	0	0	0	10	28	77
3/12/2003	2:51:17	34.09	0.0	32.4	32.9	0.5	0	0	0	10	28	77
3/12/2003	2:51:18	34.08	0.0	32.4	32.9	0.5	0	0	0	10	28	77
3/12/2003	2:51:19	34.08	0.0	32.4	32.9	0.5	0	0	0	10	28	77
3/12/2003	2:51:20	34.07	0.0	32.4	32.9	0.5	0	0	0	10	28	77
3/12/2003	2:51:21	34.07	0.0	32.4	32.9	0.5	0	0	0	10	28	77
3/12/2003	2:51:22	34.06	0.0	32.5	32.9	0.5	0	0	0	10	28	77
3/12/2003	2:51:23	34.77	9.8	32.4	32.9	0.5	1	0	0	10	28	77
3/12/2003	2:51:24	20.66	12.0	32.4	32.9	0.5	1	0	0	10	28	77
3/12/2003	2:51:25	5.30	8.0	32.4	32.9	0.5	0	1	0	10	28	77
3/12/2003	2:51:26	18.72	0.6	32.5	33.0	0.5	0	1	0	10	28	77
3/12/2003	2:51:27	13.22	-0.3	32.4	33.1	0.5	0	1	0	10	28	77
3/12/2003	2:51:28	16.06	-0.8	32.5	33.1	0.5	0	1	0	10	28	77
3/12/2003	2:51:29	21.78	-0.1	32.4	33.1	0.5	0	1	0	10	28	77
3/12/2003	2:51:30	22.33	0.4	32.5	33.1	0.5	0	1	0	10	28	77
3/12/2003	2:51:31	23.62	0.4	32.5	33.2	0.5	0	1	0	10	28	77
3/12/2003	2:51:32	24.58	0.4	32.5	33.2	0.5	0	1	0	10	28	77
3/12/2003	2:51:33	25.80	0.4	32.5	33.2	0.5	0	1	0	10	28	77
3/12/2003	2:51:34	26.84	0.3	32.5	33.2	0.5	0	1	0	10	28	77
3/12/2003	2:51:35	27.89	0.3	32.5	33.1	0.5	0	1	0	10	28	77
3/12/2003	2:51:36	28.91	0.2	32.5	33.1	0.5	0	1	0	10	28	77
3/12/2003	2:51:37	29.84	0.2	32.5	33.1	0.5	0	1	0	10	28	77
3/12/2003	2:51:38	30.75	0.2	32.5	33.2	0.5	0	1	0	10	28	77
3/12/2003	2:51:39	31.62	0.2	32.5	33.2	0.5	0	1	0	10	28	77
3/12/2003	2:51:40	32.40	0.1	32.5	33.2	0.5	0	1	0	10	28	77
3/12/2003	2:51:41	33.07	0.1	32.5	33.2	0.5	0	1	0	10	28	77
3/12/2003	2:51:42	33.65	0.1	32.5	33.2	0.5	0	1	0	10	28	77
3/12/2003	2:51:43	34.18	0.1	32.6	33.2	0.5	0	1	0	10	28	77
3/12/2003	2:51:44	34.64	0.1	32.6	33.2	0.5	0	1	0	10	28	77
3/12/2003	2:51:45	35.01	0.1	32.6	33.2	0.5	0	1	0	10	28	77
3/12/2003	2:51:46	35.32	0.1	32.6	33.2	0.5	0	1	0	10	28	77
3/12/2003	2:51:47	35.54	0.0	32.6	33.1	0.5	0	1	0	10	28	77
3/12/2003	2:51:48	35.68	0.0	32.6	33.1	0.5	0	1	0	10	28	77
3/12/2003	2:51:49	35.71	0.0	32.6	33.1	0.5	0	1	0	10	28	77
3/12/2003	2:51:50	35.64	0.0	32.6	33.1	0.5	0	1	0	10	28	77
3/12/2003	2:51:51	35.58	0.0	32.6	33.1	0.5	0	1	0	10	28	77
3/12/2003	2:51:52	35.57	0.0	32.6	33.1	0.5	0	1	0	26.6	28	77
3/12/2003	2:51:53	35.52	0.0	32.6	33.1	0.5	0	1	0	26.6	28	77
3/12/2003	2:51:54	35.45	0.0	32.6	33.1	0.5	0	1	0	26.6	28	77
3/12/2003	2:51:55	35.43	0.0	32.6	33.1	0.5	0	1	0	26.6	28	77
3/12/2003	2:51:56	35.41	0.0	32.6	33.2	0.5	0	1	0	26.6	28	77
3/12/2003	2:51:57	35.38	0.0	32.6	33.2	0.5	0	1	0	26.6	28	77
3/12/2003	2:51:58	35.36	0.0	32.6	33.2	0.5	0	1	0	26.6	28	77
3/12/2003	2:51:59	35.32	0.0	32.7	33.2	0.5	0	1	0	26.6	28	77

PJM4A_031203_1147													
DATE	TIME	PJM Tank Level (inches)	Pulse Tube Pressure (psig)	Heater Outlet Temp TC8 (°C)	Tank Bottom Temp TC10 (°C)	Recirc Pump Flow (gpm)	Pressure solenoid position	Vacuum solenoid position	Vent solenoid position	Pressure Stop Set (inches)	Vacuum Stop Set (inches)	Total Cycle Time (sec)
3/12/2003	11:46:22	19.09	0.0	27.0	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:46:39	19.09	0.0	27.0	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:46:40	19.08	0.0	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:46:41	19.08	0.0	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:46:42	19.08	0.0	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:46:43	19.07	0.0	26.9	26.6	0.4	1	0	0	16.35	16	77
3/12/2003	11:46:44	18.18	4.9	26.9	26.6	0.4	1	0	0	16.35	16	77
3/12/2003	11:46:45	10.62	4.1	26.9	26.6	0.4	0	1	0	16.35	16	77
3/12/2003	11:46:46	14.89	0.6	26.9	26.6	0.4	0	1	0	16.35	16	77
3/12/2003	11:46:47	16.35	0.3	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:46:48	13.93	0.4	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:46:49	14.83	0.4	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:46:50	15.39	0.3	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:46:51	15.06	0.3	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:46:52	15.65	0.3	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:46:53	16.36	0.2	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:46:54	16.98	0.2	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:46:55	17.37	0.2	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:46:56	17.69	0.2	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:46:57	18.00	0.1	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:46:58	18.30	0.1	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:46:59	18.52	0.1	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:47:00	18.68	0.1	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:47:01	18.80	0.1	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:47:02	18.91	0.1	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:47:03	19.03	0.0	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:47:04	19.13	0.0	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:47:05	19.18	0.0	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:47:06	19.21	0.0	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:47:07	19.21	0.0	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:47:08	19.20	0.0	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:47:09	19.19	0.0	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:47:10	19.19	0.0	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:47:11	19.18	0.0	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:47:12	19.18	0.0	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:47:13	19.18	0.0	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:47:14	19.18	0.0	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:47:15	19.17	0.0	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:47:16	19.16	0.0	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:47:17	19.16	0.0	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:47:18	19.16	0.0	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:47:19	19.16	0.0	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:47:20	19.16	0.0	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:47:21	19.16	0.0	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:47:22	19.15	0.0	26.9	26.6	0.4	0	0	1	16.35	16	77
3/12/2003	11:47:23	19.15	0.0	26.9	26.6	0.4	0	0	1	16.35	16	77

APPENDIX K

Experimental Data: Crossflow Filter Test Rig Operations Data

<u>Appendix Contents</u>

Nomenclature for Data Sheets

- Solenoid, 1=yes and 0=no for pressure to the backpulse piston
- FLTRT (^{o}C) T2, Filtrate temperature in filter at exit of the housing
- CL LOOP (^{o}C) T3, Temperature of the liquid in the cleaning loop
- SL LOOP (^{o}C) T1, Temperature of the liquid in the slurry loop at the slurry reservoir
- UP AMB (^{o}C) T4, Ambient temperature at the top of the crossflow test rig-3rd level
- BOT AMB (^{o}C) T5, Ambient temperature at the bottom of the crossflow test rig-1st level
- BOT DP (psid) dP2, Differential pressure between the filter slurry entrance and the bottom filtrate exit
- FLTR (psig) P1, pressure at the filter slurry entrance
- FLTR DP (psid) dP1, Differential pressure between the filter slurry entrance and exit
- TOP DP (psid) dP3, Differential pressure between the filter slurry exit and the top filtrate exit
- FLTRATE (psig) P2, Pressure at the filtrate exit
- BP (psig) P3, Air pressure applied to the backpulse piston
- SL FLOW (gpm) Q1, Flow rate of the slurry
- FLTR FLOW (gpm) Q2, flow rate of the filtrate (low range meter used for slurry runs)
- HI FLTR FLOW (gpm) Q3, Flow rate of the filtrate (high range meter used for water runs)
- Temp corr factor, Factor to correct for temperature variation from 25 ^{o}C equal to $e^{(2500)(1/(273 + T1)-1/298))}$
- Temp corr flow (gpm/ft^2), Filtrate flow per unit area of filter calculated by dividing the total filtrate flow by the area of the filter (2.29 ft^2) and multiplying by the temperature correction factor.

- Axial Vel (ft/sec), Axial tube velocity calculated by dividing the total slurry loop flow by the crosectional area of seven 3/8” ID tubes (0.415 ft^2)

- Avg TMP (psid), calculated by averaging BOT DP and TOP DP

Note: the data for FLTR DP, dP1, and FLTRATE, P2, is not shown for some files as the root valves to the rosemount pressure transducers were not correctly valved in. This was identified while cleaning the Crossflow Test Rig and corrected on 10/10/01.

Experimental data:

Data Set	Solution	Done on
Waterrun_091001_0747	DIF Water	9/10/01
Xflow1_092601_1800	Batch #1 AN-107 Simulant	9/26/01
Xflow1_092701_0628	Batch #1 AN-107 Simulant	9/27/01
Xflow1_092801_0717	Batch #1 AN-107 Simulant	9/28/01
Xflow1_100101_0955	Batch #1 AN-107 Simulant	10/1/01
Xflow1_100201_0702	Batch #1 AN-107 Simulant	10/2/01
Xflow1_101501_0837	DIF Water	10/15/01
Xflow2_102301_1011	Batch #2 AN-107 Simulant	10/23/01
Xflow2_102401_0630	Batch #2 AN-107 Simulant	10/24/01
Xflow2_102501_0700	Batch #2 AN-107 Simulant	10/25/01
Xflow2_110101_1045	DIF Water	11/01/01

The first page of each data set contained in the CD follows:

WATERRUN_091001_0747																				
Raw Data																	Calculations			
DATE	TIME	Sol	FLTRT (°C) T2	CL LOOP (°C) T3	SL LOOP (°C) T1	UP AMB (°C) T4	BOT AMB (°C) T5	BOT DP (psid) dP2	FLTR (psig) P1	FLTR DP (psid) dP1	TOP DP (psig) dP3	FLTRATE (psig) P2	BP (psig) P3	SL FLOW (gpm) Q1	FLTR FLOW (gpm) Q2	HI FLTR FLOW (gpm) Q3	Temp corr flow (gpm/ft^2)	Axial Vel (ft/sec)	Avg TMP (psid)	Temp corr factor
9/10/2001	8:49	0	23.5	21.9	23.5	22.2	21.6	9.1	17.4	-0.1	8.4	0.1	0	13.1	1.210	1.146	0.521	5.4	8.8	1.042
9/10/2001	8:50	0	23.6	21.9	23.6	22.2	21.7	11.5	17.5	-0.1	11.0	0.1	0	12.9	0.954	0.905	0.412	5.3	11.2	1.042
9/10/2001	8:51	0	23.6	21.9	23.6	22.2	21.7	12.0	18.3	-0.1	11.2	0.1	0	10.6	0.948	0.891	0.405	4.4	11.6	1.041
9/10/2001	8:52	0	23.7	21.9	23.6	22.3	21.7	11.2	16.6	-0.1	10.9	0.1	0	10.1	0.885	0.837	0.380	4.2	11.1	1.040
9/10/2001	8:53	0	23.7	21.9	23.6	22.3	21.8	11.1	16.1	-0.1	10.8	0.1	0	9.8	0.856	0.807	0.366	4.1	10.9	1.039
9/10/2001	8:54	0	23.8	21.9	23.7	22.4	21.8	10.4	15.2	-0.1	10.6	0.1	0	9.1	0.838	0.793	0.359	3.8	10.5	1.037
9/10/2001	8:55	0	23.8	21.9	23.7	22.4	21.8	10.5	15.1	-0.1	10.6	0.1	0	10.2	0.822	0.778	0.352	4.2	10.6	1.037
9/10/2001	8:56	0	23.8	21.9	23.7	22.4	21.8	10.9	15.5	-0.1	10.4	0.1	0	10.1	0.820	0.773	0.350	4.2	10.7	1.036
9/10/2001	8:57	0	23.9	21.9	23.8	22.4	21.8	10.9	15.5	-0.1	10.7	0.1	0	10.1	0.817	0.770	0.348	4.2	10.8	1.035
9/10/2001	8:58	0	23.9	21.9	23.8	22.4	21.8	13.4	20.0	-0.1	13.0	0.1	0	11.6	0.961	0.920	0.415	4.8	13.2	1.034
9/10/2001	8:59	0	24.0	21.9	23.9	22.4	21.8	18.4	29.4	-0.1	18.3	0.1	0	12.1	1.211	1.317	0.593	5.0	18.3	1.032
9/10/2001	9:00	0	24.1	21.9	23.9	22.4	21.8	18.7	30.0	-0.1	18.4	0.1	0	10.0	1.211	1.349	0.607	4.1	18.5	1.030
9/10/2001	9:01	0	24.2	21.9	24.0	22.4	21.9	18.7	30.0	-0.1	18.6	0.1	0	9.1	1.211	1.352	0.607	3.8	18.6	1.028
9/10/2001	9:02	0	24.3	21.9	24.1	22.4	21.9	18.9	30.2	-0.1	19.1	0.1	0	9.1	1.211	1.354	0.606	3.8	19.0	1.025
9/10/2001	9:03	0	24.4	21.9	24.2	22.4	21.9	24.1	43.3	-0.1	23.5	0.1	0	10.9	1.211	1.598	0.714	4.5	23.8	1.024
9/10/2001	9:04	0	24.5	21.9	24.3	22.4	21.9	24.1	45.8	-0.1	23.6	0.1	0	9.7	1.211	1.702	0.757	4.0	23.8	1.019
9/10/2001	9:05	0	24.7	21.9	24.4	22.4	21.9	23.8	45.2	-0.1	23.3	0.1	0	10.6	1.211	1.681	0.746	4.4	23.6	1.017
9/10/2001	9:06	0	24.8	21.9	24.6	22.5	21.9	23.4	45.2	-0.1	23.8	0.1	0	9.6	1.211	1.686	0.745	4.0	23.6	1.012
9/10/2001	9:07	0	24.9	21.9	24.7	22.5	21.9	23.6	44.9	-0.1	23.1	0.1	0	9.3	1.211	1.692	0.746	3.9	23.3	1.009
9/10/2001	9:08	0	25.1	21.9	24.8	22.5	21.9	24.1	45.9	-0.1	23.6	0.1	0	8.6	1.211	1.696	0.744	3.6	23.8	1.005
9/10/2001	9:09	0	25.2	21.9	24.9	22.5	21.9	26.5	56.2	-0.1	26.8	0.1	0	9.7	1.211	1.912	0.837	4.0	26.7	1.002
9/10/2001	9:10	0	25.4	21.9	25.1	22.5	22.0	27.7	59.9	-0.1	27.6	0.1	0	10.2	1.211	1.976	0.860	4.2	27.6	0.997
9/10/2001	9:11	0	25.6	21.9	25.2	22.5	22.0	28.0	60.7	-0.1	27.5	0.1	0	10.0	1.211	1.987	0.862	4.1	27.7	0.993
9/10/2001	9:12	0	25.8	21.9	25.5	22.6	22.0	27.8	60.5	-0.1	27.8	0.1	0	9.4	1.211	1.991	0.858	3.9	27.8	0.987
9/10/2001	9:13	0	26.0	21.9	25.7	22.6	22.0	27.3	59.9	-0.1	27.4	0.1	0	9.3	1.211	1.996	0.855	3.8	27.3	0.981
9/10/2001	9:14	0	26.1	22.0	26.0	22.6	22.0	27.4	50.7	-0.1	23.5	0.1	0	31.3	1.211	1.741	0.740	13.0	25.5	0.973
9/10/2001	9:15	0	26.2	21.9	26.1	22.6	22.0	24.9	42.8	-0.1	21.5	0.1	0	30.3	1.211	1.583	0.669	12.6	23.2	0.968
9/10/2001	9:16	0	26.4	22.0	26.3	22.6	22.0	25.6	44.7	-0.1	22.0	0.1	0	30.9	1.211	1.613	0.678	12.8	23.8	0.963
9/10/2001	9:17	0	26.5	22.0	26.5	22.6	22.0	25.8	45.2	-0.1	22.4	0.1	0	29.8	1.211	1.631	0.682	12.4	24.1	0.958
9/10/2001	9:18	0	26.7	22.0	26.7	22.6	22.0	25.7	45.0	-0.1	22.1	0.1	0	30.2	1.211	1.625	0.676	12.5	23.9	0.953
9/10/2001	9:19	0	26.9	22.0	26.9	22.6	22.0	25.5	45.1	-0.1	22.4	0.1	0	30.1	1.211	1.628	0.674	12.5	23.9	0.948

Xflow1_092601_1800

Raw Data															Calculations			
DATE	TIME	Sol	FLTRT (°C) T2	CL LOOP (°C) T3	SL LOOP (°C) T1	UP AMB (°C) T4	BOT AMB (°C) T5	BOT DP (psid) dP2	FLTR (psig) P1	TOP DP (psig) dP3	PISTON (psig) P3	SL FLOW (gpm) Q1	FLTR FLOW (gpm) Q2	HI FLTR FLOW (gpm) Q3	Temp corr factor	Temp corr flow (gpm/ft^2)	Axial Velocity (ft/sec)	Avg TMP (psid)
9/26/2001	6:09:00 PM	0	23.13	22.61	44.016	23.62	22.74	4.16	3.39	5.08	-0.08	-0.18	0.010	-0.02	0.605	0.0026	-0.1	4.6
9/26/2001	6:10:00 PM	0	23.20	22.63	43.964	24.00	22.81	4.16	3.39	5.08	-0.08	-0.18	0.010	-0.02	0.605	0.0026	-0.1	4.6
9/26/2001	6:11:00 PM	0	23.28	22.64	42.729	24.28	22.84	5.51	5.57	4.54	-0.08	1.71	0.010	-0.02	0.624	0.0027	0.7	5.0
9/26/2001	6:12:00 PM	0	23.54	22.65	39.937	24.65	22.92	0.33	7.68	-0.81	-0.08	9.53	0.010	-0.02	0.670	0.0029	4.0	-0.2
9/26/2001	6:13:00 PM	0	23.46	22.66	39.117	24.93	23.00	0.52	7.99	-0.75	-0.08	10.80	0.010	-0.02	0.684	0.0030	4.5	-0.1
9/26/2001	6:14:00 PM	0	23.65	22.66	38.180	25.14	23.07	-0.99	3.39	0.70	-0.08	-0.18	0.010	-0.02	0.701	0.0031	-0.1	-0.1
9/26/2001	6:15:00 PM	0	23.49	22.68	33.366	25.32	23.11	-0.70	3.36	0.94	-0.08	-0.18	0.010	-0.02	0.795	0.0035	-0.1	0.1
9/26/2001	6:16:00 PM	0	23.49	22.69	36.089	25.35	23.17	5.44	10.97	0.10	-0.09	29.91	0.010	-0.02	0.740	0.0032	12.4	2.8
9/26/2001	6:17:00 PM	0	23.41	22.72	34.907	25.48	23.24	6.55	11.20	1.02	-0.08	29.84	0.010	-0.02	0.763	0.0033	12.4	3.8
9/26/2001	6:18:00 PM	0	23.40	22.71	33.821	25.53	23.26	20.88	25.67	9.95	-0.08	43.50	0.010	-0.02	0.786	0.0034	18.1	15.4
9/26/2001	6:19:00 PM	0	33.58	22.73	32.719	25.61	23.29	19.21	25.72	8.22	-0.08	44.06	0.010	-0.02	0.809	0.0035	18.3	13.7
9/26/2001	6:20:00 PM	0	32.91	22.73	31.708	25.61	23.33	17.64	25.82	6.51	-0.08	44.08	0.243	0.22	0.831	0.0882	18.3	12.1
9/26/2001	6:21:00 PM	0	32.56	22.75	30.731	25.63	23.36	13.78	25.96	2.81	-0.08	43.95	0.010	-0.02	0.854	0.0037	18.2	8.3
9/26/2001	6:22:00 PM	0	31.88	22.76	29.797	25.63	23.38	15.55	25.69	4.68	-0.08	43.90	0.165	0.13	0.876	0.0631	18.2	10.1
9/26/2001	6:23:00 PM	0	31.25	22.76	28.906	25.60	23.38	16.10	25.70	5.06	-0.08	43.70	0.149	0.12	0.897	0.0584	18.1	10.6
9/26/2001	6:24:00 PM	0	30.42	22.77	27.983	25.58	23.43	16.28	25.75	5.50	-0.08	43.78	0.160	0.13	0.920	0.0643	18.2	10.9
9/26/2001	6:25:00 PM	0	31.17	22.79	27.210	25.61	23.44	16.53	25.93	5.52	-0.07	43.50	0.151	0.12	0.940	0.0620	18.1	11.0
9/26/2001	6:26:00 PM	0	30.91	22.79	26.395	25.55	23.48	16.34	25.41	5.67	-0.08	43.60	0.136	0.11	0.962	0.0571	18.1	11.0
									25.70			43.69			Average	0.0610	18.1	10.7
9/26/2001	6:27:00 PM	0	29.99	22.81	25.599	25.59	23.53	12.81	25.49	2.14	-0.08	43.06	0.010	-0.02	0.983	0.0043	17.9	7.5
9/26/2001	6:28:00 PM	0	29.90	22.81	24.886	25.59	23.56	9.18	25.51	-1.47	-0.08	43.04	0.010	-0.02	1.003	0.0044	17.9	3.9
9/26/2001	6:29:00 PM	0	29.75	22.82	24.184	25.57	23.59	9.64	25.75	-1.48	-0.08	43.18	0.010	-0.02	1.023	0.0045	17.9	4.1
9/26/2001	6:30:00 PM	0	29.37	22.83	23.496	25.55	23.62	9.42	25.69	-1.12	-0.08	43.18	0.010	-0.02	1.043	0.0046	17.9	4.2
9/26/2001	6:31:00 PM	0	29.10	22.84	22.826	25.53	23.65	9.54	25.80	-1.09	-0.08	42.92	0.010	-0.02	1.064	0.0046	17.8	4.2
9/26/2001	6:32:00 PM	0	28.74	22.84	24.088	25.46	23.68	9.51	25.88	-1.37	-0.08	43.16	0.010	-0.02	1.026	0.0045	17.9	4.1
9/26/2001	6:33:00 PM	0	28.23	22.86	25.498	25.45	23.68	9.31	25.74	-1.31	-0.07	43.31	0.010	-0.02	0.986	0.0043	18.0	4.0
9/26/2001	6:34:00 PM	0	28.05	22.87	24.905	25.47	23.72	9.14	25.53	-1.50	-0.07	43.33	0.010	-0.02	1.003	0.0044	18.0	3.8
9/26/2001	6:35:00 PM	1	29.44	22.88	24.251	25.46	23.73	9.17	26.17	-1.97	48.94	43.34	0.010	-0.02	1.021	0.0045	18.0	3.6
9/26/2001	6:36:00 PM	0	26.34	22.89	23.653	25.49	23.78	11.34	25.97	0.63	-0.07	43.02	0.010	-0.02	1.039	0.0045	17.9	6.0
9/26/2001	6:37:00 PM	0	25.61	22.90	23.094	25.42	23.75	16.24	26.05	5.17	-0.07	43.24	0.121	0.09	1.055	0.0558	17.9	10.7
9/26/2001	6:38:00 PM	0	25.00	22.90	22.533	25.39	23.78	18.50	28.74	10.43	-0.07	36.17	0.164	0.13	1.073	0.0768	15.0	14.5
9/26/2001	6:39:00 PM	0	24.48	22.91	22.013	25.43	23.79	19.55	28.39	11.61	-0.07	36.31	0.150	0.12	1.089	0.0713	15.1	15.6
9/26/2001	6:40:00 PM	0	24.14	22.92	21.512	25.44	23.82	18.31	26.95	8.40	-0.07	40.60	0.135	0.10	1.104	0.0651	16.8	13.4
9/26/2001	6:41:00 PM	0	24.07	22.94	21.090	25.35	23.82	16.37	25.12	4.86	-0.07	44.89	0.076	0.05	1.118	0.0371	18.6	10.6
9/26/2001	6:42:00 PM	0	23.85	22.94	20.613	25.34	23.84	14.78	23.39	1.00	-0.08	48.99	0.046	0.02	1.134	0.0228	20.3	7.9
9/26/2001	6:43:00 PM	0	23.79	22.96	20.399	25.38	23.81	15.19	23.73	0.39	-0.07	50.17	0.043	-0.02	1.141	0.0214	20.8	7.8
9/26/2001	6:44:00 PM	0	24.13	22.98	20.628	25.27	23.78	10.27	17.49	-1.78	-0.07	45.89	0.010	-0.02	1.133	0.0049	19.0	4.2
9/26/2001	6:45:00 PM	0	24.58	22.98	20.831	25.10	23.72	10.54	17.29	-1.76	-0.07	45.58	0.010	-0.02	1.126	0.0049	18.9	4.4

Xflow1_092701_0628

Raw Data														Calculations			
DATE	TIME	Sol	FLTRT (°C) T2	CL LOOP (°C) T3	SL LOOP (°C) T1	UP AMB (°C) T4	BOT AMB (°C) T5	BOT DP (psid) dP2	FLTR (psig) P1	TOP DP (psig) dP3	BP (psig) P3	SL FLOW (gpm) Q1	FLTR FLOW (gpm) Q2	Temp corr flow (gpm/ft^2)	Axial Vel (ft/sec)	Avg TMP (psid)	Temp corr factor
9/27/2001	6:28	0	19.9	19.1	17.5	17.7	17.7	0.1	-2.3	0.3	0	-0.2	0.010	0.0054	-0.1	0.2	1.244
9/27/2001	6:29	0	19.9	19.0	17.5	17.6	17.7	0.1	-2.3	0.3	0	-0.2	0.010	0.0054	-0.1	0.2	1.243
9/27/2001	6:30	0	19.9	19.0	21.8	17.7	17.7	13.4	11.4	7.2	0	31.7	0.010	0.0048	13.2	10.3	1.095
9/27/2001	6:31	0	20.5	19.0	21.8	17.7	17.7	13.7	13.8	9.8	0	24.6	0.010	0.0048	10.2	11.8	1.094
9/27/2001	6:32	0	20.8	19.0	21.9	17.7	17.7	9.7	11.6	3.5	0	31.7	0.010	0.0048	13.2	6.6	1.092
9/27/2001	6:33	0	21.1	19.0	22.0	17.8	17.7	20.2	26.3	10.1	0	40.9	0.010	0.0048	17.0	15.2	1.088
9/27/2001	6:34	0	21.2	19.0	22.2	17.8	17.7	14.6	25.3	3.0	0	44.6	0.010	0.0047	18.5	8.8	1.082
9/27/2001	6:35	0	21.5	19.0	22.4	17.8	17.8	14.6	26.0	4.8	0	40.2	0.010	0.0047	16.7	9.7	1.077
9/27/2001	6:36	0	21.7	19.0	22.6	17.8	17.8	13.4	25.5	3.8	0	40.0	0.010	0.0047	16.6	8.6	1.071
9/27/2001	6:37	0	22.0	19.0	22.8	17.8	17.8	15.0	24.5	3.4	0	44.0	0.010	0.0047	18.2	9.2	1.065
9/27/2001	6:38	0	22.1	19.0	22.9	17.8	17.8	13.7	24.6	1.8	0	44.8	0.012	0.0056	18.6	7.7	1.060
9/27/2001	6:39	0	22.3	19.0	23.1	17.8	17.8	12.9	24.6	1.1	0	45.0	0.012	0.0055	18.7	7.0	1.054
9/27/2001	6:40	0	22.1	19.0	23.1	17.8	17.8	-2.7	-2.2	-2.5	0	-0.2	0.010	0.0046	-0.1	-2.6	1.057
9/27/2001	6:41	0	22.3	19.0	23.0	17.8	17.8	-0.7	-2.3	-0.5	0	-0.2	0.010	0.0046	-0.1	-0.6	1.058
9/27/2001	6:42	0	22.2	19.0	22.9	17.7	17.8	-0.2	-2.3	0.0	0	-0.2	0.010	0.0046	-0.1	-0.1	1.061

The wire from the FLTR FLOW gauge was damaged causing intermittant readings. It was not fixed until 9/28/01.

The FLTR FLOW readings above are not valid.

Xflow_092801_0717																	
Raw Data														Calculations			
DATE	TIME	Sol	FLTRT (°C) T2	CL LOOP (°C) T3	SL LOOP (°C) T1	UP AMB (°C) T4	BOT AMB (°C) T5	BOT DP (psid) dP2	FLTR (psig) P1	TOP DP (psig) dP3	BP (psig) P3	SL FLOW (gpm) Q1	FLTR FLOW (gpm) Q2	Temp corr flow (gpm/ft^2)	Axial Vel (ft/sec)	Avg TMP (psid)	Temp corr factor
9/28/2001	7:17	0	20.5	20.5	19.3	20.1	20.0	0.1	-2.3	0.3	0	-0.2	0.010	0.0051	-0.1	0.2	1.179
9/28/2001	7:18	0	20.5	20.5	20.6	20.1	20.0	11.0	8.8	5.8	0	26.1	0.010	0.0049	10.8	8.4	1.132
9/28/2001	7:19	0	20.5	20.5	20.8	20.2	20.0	11.8	11.2	5.8	0	31.5	0.010	0.0049	13.1	8.8	1.127
9/28/2001	7:20	0	20.6	20.5	20.9	20.3	20.0	22.5	24.8	10.9	0	45.6	0.010	0.0049	18.9	16.7	1.123
9/28/2001	7:21	0	20.7	20.5	21.2	20.3	20.0	16.5	24.8	4.5	0	45.3	0.010	0.0049	18.8	10.5	1.116
9/28/2001	7:22	0	20.9	20.5	21.4	20.3	20.0	12.6	24.0	-0.3	0	45.1	0.010	0.0048	18.7	6.2	1.109
9/28/2001	7:23	0	21.0	20.5	21.6	20.3	20.1	12.4	23.9	-0.3	0	-25.1	0.011	0.0053	-10.4	6.1	1.103
9/28/2001	7:24	0	21.1	20.5	21.8	20.4	20.1	12.2	23.8	-0.7	0	-25.1	0.010	0.0048	-10.4	5.7	1.095
9/28/2001	7:25	0	21.3	20.5	22.0	20.3	20.1	12.4	23.6	-0.1	0	47.0	0.010	0.0048	19.5	6.1	1.089
9/28/2001	7:26	0	21.5	20.5	22.2	20.4	20.1	12.2	23.9	-0.6	0	-25.1	0.010	0.0047	-10.4	5.8	1.082
9/28/2001	7:27	0	21.6	20.5	22.4	20.3	20.1	12.2	23.9	-0.4	0	-25.1	0.011	0.0052	-10.4	5.9	1.075
9/28/2001	7:28	0	21.8	20.5	22.7	20.3	20.1	12.4	24.1	-0.7	0	-25.1	0.010	0.0047	-10.4	5.9	1.069
9/28/2001	7:29	0	22.0	20.5	22.9	20.4	20.2	12.3	23.9	-0.9	0	-25.1	0.010	0.0046	-10.4	5.7	1.063
9/28/2001	7:30	0	22.2	20.5	23.1	20.3	20.2	12.3	23.9	-0.6	0	47.1	0.010	0.0046	19.5	5.8	1.057
9/28/2001	7:31	0	22.3	20.5	23.3	20.4	20.2	12.2	23.8	-0.7	0	46.9	0.010	0.0046	19.5	5.8	1.051
9/28/2001	7:32	0	22.6	20.5	23.5	20.4	20.2	15.4	27.4	6.4	0	38.4	0.011	0.0050	15.9	10.9	1.045
9/28/2001	7:33	0	22.8	20.5	23.6	20.4	20.2	22.7	34.6	20.7	0	18.0	0.084	0.0381	7.5	21.7	1.040
9/28/2001	7:34	0	23.0	20.5	23.8	20.4	20.3	48.7	59.6	47.7	0	12.8	0.133	0.0601	5.3	48.2	1.035
9/28/2001	7:35	0	23.2	20.5	23.9	20.4	20.3	58.0	67.9	56.9	0	8.5	0.110	0.0495	3.5	57.4	1.030
9/28/2001	7:36	0	23.6	20.5	24.2	20.5	20.3	61.1	68.7	60.4	0	8.0	0.010	0.0045	3.3	60.7	1.023
9/28/2001	7:37	0	23.9	20.5	24.5	20.5	20.4	59.2	68.6	58.2	0	8.2	0.074	0.0328	3.4	58.7	1.014
9/28/2001	7:38	0	24.1	20.5	24.7	20.5	20.4	58.1	67.1	57.9	0	8.1	0.067	0.0295	3.3	58.0	1.008
9/28/2001	7:39	0	24.3	20.5	25.0	20.5	20.4	59.6	68.7	58.9	0	8.1	0.061	0.0266	3.4	59.2	1.000
9/28/2001	7:40	0	24.5	20.5	25.2	20.5	20.4	59.1	68.0	58.9	0	8.0	0.057	0.0247	3.3	59.0	0.994
9/28/2001	7:41	0	24.7	20.5	25.5	20.5	20.5	59.6	68.6	58.7	0	8.0	0.055	0.0237	3.3	59.1	0.986
9/28/2001	7:42	0	24.9	20.5	25.7	20.5	20.5	59.5	68.0	59.3	0	7.6	0.052	0.0222	3.2	59.4	0.980
9/28/2001	7:43	0	25.1	20.5	26.0	20.5	20.5	60.0	68.9	58.2	0	7.9	0.050	0.0212	3.3	59.1	0.972
9/28/2001	7:44	0	25.4	20.5	26.3	20.6	20.5	58.8	67.2	58.7	0	7.9	0.048	0.0202	3.3	58.7	0.965
9/28/2001	7:45	0	25.6	20.5	26.5	20.6	20.6	59.3	67.9	58.2	0	7.9	0.046	0.0193	3.3	58.7	0.959
9/28/2001	7:46	0	25.8	20.5	26.7	20.6	20.6	59.8	68.4	59.2	0	7.8	0.045	0.0188	3.2	59.5	0.955
9/28/2001	7:47	0	26.1	20.5	26.9	20.6	20.6	59.2	67.6	58.8	0	7.8	0.045	0.0187	3.2	59.0	0.949
9/28/2001	7:48	0	26.2	20.5	27.1	20.7	20.7	59.4	67.9	59.2	0	7.8	0.039	0.0161	3.2	59.3	0.944
9/28/2001	7:49	0	26.5	20.5	27.3	20.8	20.7	60.2	68.3	59.4	0	7.7	0.046	0.0188	3.2	59.8	0.937
9/28/2001	7:50	0	26.6	20.5	27.5	20.7	20.7	60.5	68.4	58.8	0	7.7	0.042	0.0171	3.2	59.6	0.932
9/28/2001	7:51	0	26.9	20.5	27.8	20.7	20.7	60.4	68.2	59.3	0	10.4	0.041	0.0166	4.3	59.8	0.925
9/28/2001	7:52	0	27.1	20.5	28.0	20.7	20.7	60.4	68.1	59.1	0	10.1	0.040	0.0161	4.2	59.7	0.920
9/28/2001	7:53	0	27.4	20.5	28.2	20.6	20.7	60.4	68.3	59.1	0	9.9	0.039	0.0156	4.1	59.7	0.914
9/28/2001	7:54	0	27.5	20.5	28.4	20.7	20.8	60.3	67.8	59.7	0	9.8	0.040	0.0159	4.1	60.0	0.909
9/28/2001	7:55	0	27.7	20.5	28.5	20.7	20.8	60.1	67.8	59.1	0	9.7	0.039	0.0155	4.0	59.6	0.908
9/28/2001	7:56	0	27.9	20.5	28.4	20.9	20.8	60.4	68.1	59.2	0	9.6	0.039	0.0155	4.0	59.8	0.911
9/28/2001	7:57	0	28.0	20.5	28.2	21.1	20.9	60.7	68.5	58.9	0	9.6	0.038	0.0152	4.0	59.8	0.916
9/28/2001	7:58	0	28.1	20.5	28.1	21.4	21.0	60.5	68.2	59.8	0	9.6	0.037	0.0148	4.0	60.1	0.918
9/28/2001	7:59	0	28.0	20.6	27.7	21.6	21.0	60.4	68.1	59.6	0	9.5	0.037	0.0150	4.0	60.0	0.927
9/28/2001	8:00	0	28.0	20.6	27.5	21.8	21.1	60.6	68.4	58.8	0	9.5	0.037	0.0151	3.9	59.7	0.932
9/28/2001	8:01	0	28.0	20.6	27.2	21.8	21.1	60.5	68.1	59.3	0	9.5	0.037	0.0152	3.9	59.9	0.940

Xflow11_100101_0955																		
Raw Data															Calculations			
DATE	TIME	Sol	FLTRT (°C) T2	CL LOOP (°C) T3	SL LOOP (°C) T1	UP AMB (°C) T4	BOT AMB (°C) T5	BOT DP (psid) dP2	FLTR (psig) P1	TOP DP (psig) dP3	BP (psig) P3	SL FLOW (gpm) Q1	FLTR FLOW (gpm) Q2	Temp corr flow (gpm/ft^2)	Axial Vel (ft/sec)	Avg TMP (psid)	Temp corr factor
10/1/2001	9:55	0	18.9	18.5	17.3	19.4	18.5	0.2	-2.2	0.4	0	-0.2	0.010	0.0054	-0.1	0.3	1.248
10/1/2001	9:56	0	18.9	18.5	17.4	19.4	18.6	0.2	-2.2	0.4	0	-0.2	0.010	0.0054	-0.1	0.3	1.247
10/1/2001	9:57	0	18.9	18.5	17.3	19.5	18.6	0.2	-2.2	0.4	0	-0.2	0.010	0.0054	-0.1	0.3	1.248
10/1/2001	9:58	0	18.9	18.5	17.4	19.5	18.6	0.2	-2.2	0.4	0	-0.2	0.010	0.0054	-0.1	0.3	1.246
10/1/2001	9:59	0	18.9	18.5	17.4	19.5	18.6	0.2	-2.2	0.4	0	-0.2	0.010	0.0054	-0.1	0.3	1.247
10/1/2001	10:00	0	18.9	18.5	17.4	19.5	18.6	0.2	-2.2	0.4	0	-0.2	0.010	0.0054	-0.1	0.3	1.246
10/1/2001	10:01	0	18.9	18.5	17.4	19.5	18.7	0.2	-2.2	0.4	0	-0.2	0.010	0.0054	-0.1	0.3	1.246
10/1/2001	10:02	0	18.9	18.5	17.4	19.6	18.7	0.2	-2.2	0.4	0	-0.2	0.010	0.0054	-0.1	0.3	1.245
10/1/2001	10:03	0	18.9	18.5	17.4	19.6	18.7	0.2	-2.2	0.4	0	-0.2	0.010	0.0054	-0.1	0.3	1.245
10/1/2001	10:04	0	18.9	18.5	17.4	19.6	18.7	0.2	-2.2	0.4	0	-0.2	0.010	0.0054	-0.1	0.3	1.244
10/1/2001	10:05	0	18.9	18.5	17.4	19.6	18.7	0.2	-2.2	0.4	0	-0.2	0.010	0.0054	-0.1	0.3	1.244
10/1/2001	10:06	0	18.9	18.5	17.4	19.6	18.8	0.2	-2.2	0.4	0	-0.2	0.010	0.0054	-0.1	0.3	1.244
10/1/2001	10:07	0	18.9	18.5	17.5	19.7	18.8	0.2	-2.2	0.4	0	-0.2	0.010	0.0054	-0.1	0.3	1.243
10/1/2001	10:08	0	18.9	18.5	17.5	19.7	18.8	0.2	-2.2	0.4	0	-0.2	0.010	0.0054	-0.1	0.3	1.243
10/1/2001	10:09	0	18.9	18.6	17.5	19.7	18.8	0.2	-2.2	0.4	0	-0.2	0.010	0.0054	-0.1	0.3	1.242
10/1/2001	10:10	0	18.9	18.5	17.5	19.7	18.8	0.1	-2.3	0.3	0	-0.2	0.010	0.0054	-0.1	0.2	1.243
10/1/2001	10:11	0	19.0	18.6	17.5	19.7	18.8	0.1	-2.3	0.3	0	-0.2	0.010	0.0054	-0.1	0.2	1.242
10/1/2001	10:12	0	18.9	18.6	17.5	19.7	18.9	0.1	-2.3	0.3	0	-0.2	0.010	0.0054	-0.1	0.2	1.242
10/1/2001	10:13	0	19.0	18.6	17.5	19.8	18.9	0.1	-2.3	0.3	0	-0.2	0.010	0.0054	-0.1	0.2	1.241
10/1/2001	10:14	0	19.0	18.6	19.1	19.8	18.9	16.7	14.3	13.4	0	17.4	0.010	0.0052	7.2	15.1	1.184
10/1/2001	10:15	0	19.0	18.6	19.1	19.8	18.9	30.3	28.6	25.5	0	26.7	0.011	0.0057	11.1	27.9	1.184
10/1/2001	10:16	0	19.0	18.6	19.3	19.8	19.0	29.2	28.3	24.2	0	26.8	0.010	0.0051	11.1	26.7	1.178
10/1/2001	10:17	0	19.1	18.6	19.5	19.9	19.0	57.6	57.8	48.2	0	38.9	0.010	0.0051	16.1	52.9	1.171
10/1/2001	10:18	0	19.3	18.6	19.9	19.9	19.0	54.9	57.8	45.8	0	38.9	0.011	0.0056	16.1	50.3	1.157
10/1/2001	10:19	0	19.5	18.6	20.3	19.9	19.1	51.1	57.8	41.9	0	38.9	0.010	0.0050	16.1	46.5	1.145
10/1/2001	10:20	0	19.8	18.6	20.7	20.0	19.1	45.5	58.0	35.8	0	38.8	0.010	0.0049	16.1	40.7	1.132
10/1/2001	10:21	0	20.1	18.6	21.0	20.1	19.1	44.9	57.5	35.8	0	39.0	0.010	0.0049	16.2	40.3	1.120
10/1/2001	10:22	0	20.3	18.6	21.4	20.2	19.1	47.1	57.9	37.4	0	38.9	0.010	0.0048	16.2	42.3	1.109
10/1/2001	10:23	0	20.6	18.7	21.7	20.2	19.2	46.2	57.6	37.0	0	39.0	0.045	0.0216	16.2	41.6	1.098
10/1/2001	10:24	0	21.0	18.7	22.1	20.2	19.2	46.5	57.6	37.3	0	39.1	0.050	0.0237	16.2	41.9	1.086
10/1/2001	10:25	0	21.2	18.7	22.5	20.1	19.2	46.4	57.4	37.3	0	38.9	0.051	0.0239	16.1	41.9	1.075
10/1/2001	10:26	0	21.6	18.7	22.8	20.2	19.3	46.5	57.4	36.9	0	39.1	0.058	0.0269	16.2	41.7	1.064
10/1/2001	10:27	0	21.9	18.7	23.2	20.2	19.3	46.6	57.6	37.3	0	39.1	0.050	0.0230	16.2	41.9	1.053
10/1/2001	10:28	0	22.3	18.7	23.5	20.2	19.3	46.6	57.4	37.2	0	39.3	0.051	0.0232	16.3	41.9	1.042
10/1/2001	10:29	0	22.5	18.7	23.8	20.2	19.4	46.5	57.3	37.1	0	39.2	0.052	0.0235	16.3	41.8	1.033
10/1/2001	10:30	0	22.9	18.7	24.2	20.2	19.4	46.1	56.9	37.2	0	39.3	0.050	0.0223	16.3	41.6	1.023
10/1/2001	10:31	0	23.2	18.7	24.6	20.2	19.4	46.5	57.6	37.4	0	39.3	0.051	0.0225	16.3	42.0	1.012
10/1/2001	10:32	0	23.5	18.7	24.7	20.2	19.5	46.1	56.9	37.1	0	39.2	0.051	0.0225	16.3	41.6	1.008
10/1/2001	10:33	0	23.8	18.7	24.7	20.5	19.6	46.6	57.5	37.1	0	39.3	0.051	0.0225	16.3	41.8	1.009
10/1/2001	10:34	0	24.0	18.7	24.4	20.7	19.6	46.9	57.8	37.4	0	39.1	0.051	0.0226	16.2	42.2	1.017
10/1/2001	10:35	0	24.1	18.7	24.0	20.7	19.7	46.6	57.3	37.4	0	39.1	0.051	0.0229	16.2	42.0	1.029
10/1/2001	10:36	0	24.0	18.7	23.9	20.6	19.7	46.7	57.4	37.4	0	39.2	0.050	0.0225	16.3	42.1	1.032
10/1/2001	10:37	0	23.9	18.7	24.0	20.5	19.8	46.6	57.4	37.5	0	39.2	0.050	0.0225	16.3	42.0	1.028
10/1/2001	10:38	0	23.9	18.7	24.2	20.5	19.8	46.4	57.0	37.3	0	39.3	0.051	0.0228	16.3	41.8	1.023
10/1/2001	10:39	0	23.9	18.8	24.4	20.5	19.8	46.7	57.6	37.4	0	39.2	0.051	0.0227	16.3	42.1	1.018
10/1/2001	10:40	0	24.1	18.8	24.6	20.5	19.8	46.8	57.6	37.6	0	39.4	0.052	0.0230	16.4	42.2	1.012

Xflow_100201_0702																
Raw Data													Calculations			
TIME	Sol	FLTRT (°C) T2	CL LOOP (°C) T3	SL LOOP (°C) T1	UP AMB (°C) T4	BOT AMB (°C) T5	BOT DP (psid) dP2	FLTR (psig) P1	TOP DP (psig) dP3	BP (psig) P3	SL FLOW (gpm) Q1	FLTR FLOW (gpm) Q2	Temp corr flow (gpm/ft^2)	Axial Vel (ft/sec)	Avg TMP (psid)	Temp corr factor
7:02	0	19.8	19.3	17.3	18.2	17.8	0.1	-2.2	0.4	0	-0.2	0.010	0.005	-0.1	0.2	1.247
7:03	0	19.8	19.3	21.4	18.2	17.8	61.3	59.4	51.6	0	38.3	0.010	0.005	15.9	56.5	1.107
7:04	0	20.2	19.3	21.9	18.2	17.8	57.7	58.5	48.2	0	39.0	0.010	0.005	16.2	53.0	1.093
7:05	0	20.8	19.3	22.2	18.2	17.8	52.4	58.1	43.0	0	39.0	0.010	0.005	16.2	47.7	1.083
7:06	0	21.2	19.3	22.5	18.2	17.8	45.6	58.1	36.3	0	38.8	0.010	0.005	16.1	41.0	1.074
7:07	0	21.6	19.3	22.6	18.2	17.9	45.8	57.9	36.6	0	38.9	0.010	0.005	16.1	41.2	1.071
7:08	0	21.8	19.3	22.7	18.2	17.9	47.0	57.8	38.0	0	39.1	0.010	0.005	16.2	42.5	1.066
7:09	0	22.1	19.3	23.1	18.2	17.9	46.8	58.0	37.6	0	39.1	0.043	0.020	16.2	42.2	1.056
7:10	0	22.3	19.3	23.3	18.2	17.9	47.4	58.3	37.8	0	39.1	0.048	0.022	16.2	42.6	1.049
7:11	0	22.6	19.3	23.6	18.2	17.9	47.3	58.1	38.3	0	39.1	0.048	0.022	16.2	42.8	1.041
7:12	0	22.8	19.3	23.9	18.2	17.9	47.1	57.9	37.9	0	39.1	0.048	0.022	16.2	42.5	1.033
7:13	0	23.1	19.2	24.2	18.2	18.0	47.5	58.3	38.1	0	39.2	0.050	0.022	16.3	42.8	1.024
7:14	0	23.4	19.2	24.4	18.2	18.0	47.0	57.9	37.9	0	39.1	0.049	0.022	16.2	42.5	1.017
7:15	0	23.6	19.2	24.7	18.2	18.0	46.9	57.6	37.9	0	39.1	0.049	0.022	16.2	42.4	1.009
7:16	0	23.9	19.2	25.0	18.2	18.0	47.3	58.0	37.6	0	39.2	0.049	0.021	16.3	42.4	1.001
7:17	0	24.1	19.2	25.2	18.2	18.1	46.8	57.5	37.9	0	39.3	0.050	0.022	16.3	42.3	0.994
7:18	0	24.4	19.2	25.5	18.2	18.1	47.0	57.8	37.6	0	39.4	0.049	0.021	16.4	42.3	0.986
7:19	0	24.6	19.2	25.7	18.2	18.1	47.4	58.3	38.0	0	39.4	0.050	0.021	16.3	42.7	0.979
7:20	0	24.9	19.2	26.0	18.2	18.1	46.8	57.5	37.7	0	39.5	0.050	0.021	16.4	42.3	0.972
7:21	0	25.2	19.2	26.3	18.3	18.1	47.2	58.1	37.8	0	39.2	0.052	0.022	16.3	42.5	0.964
7:22	0	25.4	19.2	26.6	18.2	18.1	47.0	57.9	37.5	0	39.3	0.051	0.021	16.3	42.3	0.957
7:23	0	25.7	19.2	26.8	18.2	18.1	46.6	57.3	37.5	0	39.4	0.051	0.021	16.4	42.1	0.951
7:24	0	25.9	19.2	27.1	18.2	18.2	47.0	57.7	37.5	0	39.5	0.051	0.021	16.4	42.2	0.944
7:25	0	26.2	19.2	27.2	18.2	18.2	47.1	57.9	37.8	0	39.6	0.053	0.022	16.4	42.4	0.941
7:26	0	26.4	19.2	27.1	18.2	18.2	47.0	57.8	37.4	0	39.4	0.051	0.021	16.3	42.2	0.943
7:27	0	26.5	19.2	27.0	18.2	18.3	46.8	57.5	37.5	0	39.4	0.051	0.021	16.3	42.1	0.947
7:28	0	26.6	19.2	26.9	18.3	18.4	47.2	57.8	37.6	0	39.6	0.050	0.021	16.4	42.4	0.948
7:29	0	26.6	19.1	26.8	18.3	18.4	47.1	57.7	37.7	0	39.4	0.051	0.021	16.4	42.4	0.950
7:30	0	26.6	19.1	26.7	18.2	18.5	47.3	57.9	37.6	0	39.3	0.050	0.021	16.3	42.4	0.954
7:31	0	26.6	19.2	26.7	18.4	18.6	46.8	57.5	37.8	0	39.4	0.051	0.021	16.3	42.3	0.954
7:32	0	26.6	19.1	26.6	18.4	18.7	47.2	57.8	37.6	0	39.3	0.052	0.022	16.3	42.4	0.956
7:33	0	26.5	19.2	26.6	18.5	18.7	46.8	57.3	37.8	0	39.4	0.050	0.021	16.3	42.3	0.956
7:34	0	26.5	19.1	26.5	18.5	18.8	47.8	58.2	37.9	0	39.4	0.050	0.021	16.3	42.8	0.958
7:35	0	26.5	19.1	26.5	18.6	18.8	46.9	57.5	37.7	0	39.5	0.050	0.021	16.4	42.3	0.959
7:36	0	26.5	19.1	26.4	18.7	18.8	47.2	57.9	37.9	0	39.3	0.049	0.021	16.3	42.5	0.961
7:37	0	26.5	19.1	26.4	18.8	18.9	47.1	57.7	37.9	0	39.3	0.050	0.021	16.3	42.5	0.962
7:38	0	26.4	19.1	26.4	18.8	18.9	46.8	57.4	37.7	0	39.5	0.049	0.021	16.4	42.3	0.963
7:39	0	26.4	19.1	26.3	18.8	18.9	47.0	57.6	37.7	0	39.3	0.050	0.021	16.3	42.4	0.964
7:40	0	26.4	19.1	26.3	18.9	19.0	47.2	57.8	37.7	0	39.3	0.049	0.021	16.3	42.4	0.965
7:41	0	26.3	19.1	26.2	18.9	19.0	46.8	57.3	37.6	0	39.0	0.049	0.021	16.2	42.2	0.967
7:42	0	26.3	19.1	26.2	19.0	19.0	46.8	57.4	37.7	0	39.2	0.049	0.021	16.3	42.2	0.968
7:43	0	26.3	19.1	26.1	19.1	19.0	47.1	57.7	37.8	0	39.3	0.048	0.020	16.3	42.5	0.969
7:44	0	26.3	19.1	26.1	19.1	19.0	47.6	58.1	37.8	0	39.3	0.049	0.021	16.3	42.7	0.969
7:45	0	26.3	19.1	26.1	19.0	19.0	47.0	57.4	37.5	0	39.3	0.049	0.021	16.3	42.2	0.970
7:46	0	26.2	19.2	26.1	19.0	19.1	47.0	57.6	37.8	0	39.2	0.049	0.021	16.3	42.4	0.969
7:47	0	26.1	19.1	26.0	19.1	19.1	46.8	57.3	37.7	0	39.3	0.049	0.021	16.3	42.3	0.972

Xflow1_101501_0837 (Deionized water runs after Batch #1 slurry filtration and filter cleaning)																				
Raw Data																	Calculations			
DATE	TIME	Sol	FLTRT (°C) T2	CL LOOP (°C) T3	SL LOOP (°C) T1	UP AMB (°C) T4	BOT AMB (°C) T5	BOT DP (psid) dP2	FLTR (psig) P1	FLTR DP (psid) dP1	TOP DP (psig) dP3	FLTRATE (psig) P2	BP (psig) P3	SL FLOW (gpm) Q1	FLTR FLOW (gpm) Q2	HI FLTR FLOW (gpm) Q3	Temp corr flow (gpm/ft^2)	Axial Vel (ft/sec)	Avg TMP (psid)	Temp corr factor
10/15/2001	8:45	1	20.2	19.8	20.4	19.7	18.9	11.0	17.2	9.6	1.7	6.7	53.8	48.5	0.01	-0.019	-0.009	20.1	6.3	1.140
10/15/2001	8:46	1	20.1	19.8	20.5	19.7	18.9	10.8	24.5	13.3	-2.7	14.1	53.9	59.2	0.01	-0.019	-0.009	24.6	4.1	1.137
10/15/2001	8:47	1	20.1	19.8	20.7	19.7	19.0	10.1	22.1	11.9	-2.1	12.5	53.8	55.3	0.01	-0.019	-0.009	22.9	4.0	1.132
10/15/2001	8:48	1	20.3	20.2	20.8	19.9	19.0	6.5	22.3	12.0	-3.2	16.3	53.8	49.5	0.01	-0.019	-0.009	20.6	1.6	1.126
10/15/2001	8:49	1	20.4	20.2	21.0	20.0	19.0	9.6	21.8	11.8	-2.4	12.7	53.8	55.2	0.01	-0.019	-0.009	22.9	3.6	1.121
10/15/2001	8:50	1	20.6	20.2	21.2	20.0	19.0	9.7	22.0	11.9	-2.2	12.6	53.9	54.4	0.01	-0.019	-0.009	22.6	3.8	1.115
10/15/2001	8:51	1	20.7	20.2	21.3	19.9	19.0	9.9	22.1	12.2	-2.0	12.6	53.8	55.9	0.01	-0.019	-0.009	23.2	4.0	1.110
10/15/2001	8:52	1	20.8	20.1	21.5	19.9	19.0	9.8	21.8	12.1	-2.0	12.6	53.8	55.3	0.01	-0.019	-0.009	22.9	3.9	1.105
10/15/2001	8:53	1	20.9	20.1	21.7	19.9	19.1	9.6	21.9	12.0	-2.1	12.7	53.8	54.4	0.01	-0.019	-0.009	22.6	3.7	1.099
10/15/2001	8:54	1	21.1	20.1	21.8	19.9	19.1	9.6	21.9	11.9	-2.3	12.6	53.8	55.7	0.01	-0.019	-0.009	23.1	3.7	1.094
10/15/2001	8:55	1	21.2	20.1	22.0	19.9	19.1	9.9	22.2	11.9	-2.1	12.7	53.9	55.2	0.01	-0.019	-0.009	22.9	3.9	1.089
10/15/2001	8:56	1	21.3	20.1	22.2	19.9	19.1	9.7	21.9	12.1	-2.2	12.7	53.8	55.3	0.01	-0.019	-0.009	23.0	3.7	1.084
10/15/2001	8:57	1	21.5	20.0	22.3	19.9	19.1	9.3	21.5	12.0	-2.0	12.7	53.8	55.4	0.01	-0.019	-0.009	23.0	3.6	1.079
10/15/2001	8:58	1	21.6	20.1	22.5	19.9	19.1	9.8	22.1	11.9	-2.0	12.7	53.8	55.7	0.01	-0.019	-0.009	23.1	3.9	1.074
10/15/2001	8:59	1	21.8	20.0	22.6	19.9	19.1	9.7	22.0	12.1	-2.2	12.7	53.9	55.4	0.01	-0.019	-0.009	23.0	3.7	1.069
10/15/2001	9:00	1	21.9	20.0	22.8	19.9	19.2	9.6	23.0	11.1	-1.2	13.9	53.8	53.5	0.01	-0.019	-0.009	22.2	4.2	1.064
10/15/2001	9:01	1	22.2	20.0	23.0	19.9	19.2	9.1	31.1	11.0	-1.7	22.4	53.8	53.3	0.01	-0.019	-0.009	22.1	3.7	1.059
10/15/2001	9:02	1	22.2	20.0	23.2	19.9	19.2	8.1	32.0	10.0	-1.9	24.3	53.8	50.3	0.01	-0.019	-0.009	20.9	3.1	1.053
10/15/2001	9:03	1	22.4	20.0	23.4	19.9	19.2	8.1	32.2	10.1	-1.4	24.4	54.0	50.4	0.01	-0.019	-0.009	20.9	3.4	1.047
10/15/2001	9:04	1	22.6	20.0	23.6	20.0	19.2	8.0	31.9	10.1	-1.8	24.3	53.8	50.8	0.01	-0.019	-0.009	21.1	3.1	1.041
10/15/2001	9:05	1	22.8	20.0	23.8	20.0	19.3	7.9	31.9	10.0	-1.8	24.5	53.8	50.6	0.01	-0.019	-0.009	21.0	3.0	1.035
10/15/2001	9:06	0	23.3	20.0	24.0	20.0	19.3	22.0	31.7	9.9	12.5	10.1	0.0	51.3	1.194	1.191	0.535	21.3	17.2	1.029
10/15/2001	9:07	0	23.9	20.0	24.1	20.0	19.3	23.0	31.6	9.9	13.4	9.2	0.0	51.1	1.158	1.110	0.497	21.2	18.2	1.025
10/15/2001	9:08	0	24.2	20.0	24.3	20.0	19.3	24.3	32.0	9.8	14.7	8.2	0.0	50.8	1.043	1.001	0.446	21.1	19.5	1.020
10/15/2001	9:09	0	24.4	20.0	24.5	20.1	19.3	25.1	32.1	9.9	15.2	7.5	0.0	51.1	0.929	0.899	0.399	21.2	20.1	1.016
10/15/2001	9:10	0	24.6	20.0	24.6	20.1	19.4	25.2	31.8	9.8	15.6	7.0	0.0	50.5	0.881	0.842	0.371	21.0	20.4	1.010
10/15/2001	9:11	0	24.7	20.0	24.8	20.1	19.4	25.7	31.9	9.9	15.8	6.7	0.0	51.5	0.82	0.781	0.343	21.4	20.8	1.005
10/15/2001	9:12	0	24.9	20.0	25.0	20.1	19.4	25.8	31.8	9.9	16.0	6.5	0.0	51.2	0.775	0.730	0.319	21.2	20.9	1.000
10/15/2001	9:13	0	25.0	20.0	25.2	20.1	19.4	19.8	31.6	9.7	10.3	12.2	0.0	51.0	1.211	1.289	0.560	21.2	15.1	0.995
10/15/2001	9:14	0	25.3	20.0	25.4	20.1	19.4	22.4	31.6	9.8	12.5	9.8	0.0	51.3	1.193	1.144	0.494	21.3	17.5	0.990
10/15/2001	9:15	0	25.4	20.0	25.6	20.2	19.5	20.9	31.8	9.9	11.2	11.4	0.0	51.5	1.211	1.321	0.568	21.4	16.0	0.985

Xflow2_102301_1011																			
Raw Data																Calculations			
DATE	TIME	Sol	FLTRT (°C) T2	CL LOOP (°C) T3	SL LOOP (°C) T1	UP AMB (°C) T4	BOT AMB (°C) T5	BOT DP (psid) dP2	FLTR (psig) P1	FLTR DP (psid) dP1	TOP DP (psig) dP3	FLTRATE (psig) P2	BP (psig) P3	SL FLOW (gpm) Q1	FLTR FLOW (gpm) Q2	Temp corr flow (gpm/ft^2)	Axial Vel (ft/sec)	Avg TMP (psid)	Temp corr factor
10/23/2001	10:55	0	22.7	22.0	23.1	23.4	22.0	17.0	20.8	13.6	3.2	5.2	0	46.1	0.021	0.0097	19.1	10.1	1.054
10/23/2001	10:56	0	22.7	22.1	23.4	23.4	22.1	41.8	47.0	24.0	17.0	6.7	0	64.7	0.018	0.0082	26.9	29.4	1.046
10/23/2001	10:57	0	22.8	22.1	23.7	23.4	22.2	50.4	58.5	11.8	38.0	9.3	0	42.6	0.018	0.0082	17.7	44.2	1.038
10/23/2001	10:58	0	22.8	22.1	23.9	23.5	22.2	47.1	58.5	11.6	35.2	12.3	0	42.4	0.018	0.0081	17.6	41.2	1.031
10/23/2001	10:59	0	22.1	22.1	24.2	23.5	22.2	54.2	58.3	11.6	42.5	4.9	0	42.7	0.010	0.0045	17.7	48.3	1.024
10/23/2001	11:00	0	22.3	22.1	24.4	23.5	22.2	54.0	58.2	11.7	42.3	4.9	0	42.8	0.010	0.0044	17.7	48.2	1.018
10/23/2001	11:01	0	22.4	22.1	24.6	23.6	22.3	54.2	58.9	11.5	42.7	4.9	0	42.1	0.010	0.0044	17.5	48.5	1.010
10/23/2001	11:02	0	22.4	22.1	24.8	23.6	22.3	53.7	58.5	11.3	42.8	4.9	0	41.9	0.010	0.0044	17.4	48.3	1.005
10/23/2001	11:03	0	23.0	22.1	25.1	23.8	22.4	53.3	58.3	11.7	42.1	5.1	0	42.6	0.010	0.0044	17.7	47.7	0.998
10/23/2001	11:04	0	23.5	22.1	25.2	24.0	22.4	52.3	58.3	11.5	41.3	6.2	0	42.3	0.010	0.0043	17.5	46.8	0.993
10/23/2001	11:05	0	24.7	22.1	25.4	24.1	22.4	50.8	58.2	11.3	40.2	7.5	0	42.0	0.010	0.0043	17.4	45.5	0.989
10/23/2001	11:06	0	24.9	22.1	25.6	24.1	22.5	50.0	58.3	11.4	39.2	8.4	0	42.4	0.010	0.0043	17.6	44.6	0.984
10/23/2001	11:07	0	25.2	22.1	25.7	24.2	22.5	49.8	58.7	11.2	38.9	8.9	0	41.8	0.111	0.0475	17.4	44.3	0.979
10/23/2001	11:08	0	25.3	22.1	25.9	24.2	22.6	49.7	58.3	11.3	39.0	9.0	0	42.0	0.112	0.0477	17.4	44.3	0.976
10/23/2001	11:09	0	25.5	22.2	26.0	24.2	22.6	49.6	58.4	11.1	38.9	8.9	0	41.7	0.111	0.0471	17.3	44.3	0.971
10/23/2001	11:10	0	25.7	22.2	26.2	24.3	22.6	49.6	58.3	11.2	39.0	8.9	0	41.7	0.110	0.0464	17.3	44.3	0.967
10/23/2001	11:11	0	25.8	22.2	26.4	24.3	22.7	49.6	58.4	11.2	38.7	8.9	0	41.9	0.108	0.0454	17.4	44.2	0.963
10/23/2001	11:12	0	26.0	22.2	26.5	24.3	22.8	49.8	58.6	11.2	38.7	8.9	0	42.0	0.110	0.0460	17.4	44.2	0.958
10/23/2001	11:13	0	26.2	22.2	26.6	24.4	22.8	49.5	58.2	11.2	38.8	8.9	0	41.7	0.108	0.0450	17.3	44.2	0.955
10/23/2001	11:14	0	26.3	22.2	26.8	24.4	22.9	49.6	58.4	11.2	39.2	8.9	0	42.3	0.107	0.0444	17.5	44.4	0.951
10/23/2001	11:15	0	26.5	22.2	26.9	24.6	22.9	49.4	58.3	11.2	38.7	8.9	0	41.3	0.107	0.0443	17.1	44.1	0.949
10/23/2001	11:16	0	26.6	22.3	27.0	24.6	22.9	50.1	59.0	11.2	38.9	8.9	0	41.7	0.106	0.0438	17.3	44.5	0.946
10/23/2001	11:17	0	26.7	22.3	27.1	24.7	23.0	49.3	58.0	11.5	38.3	8.9	0	42.4	0.105	0.0432	17.6	43.8	0.943
10/23/2001	11:18	0	26.9	22.3	27.2	24.7	23.1	49.2	58.0	11.4	38.3	8.9	0	42.2	0.104	0.0427	17.5	43.8	0.940
10/23/2001	11:19	0	27.0	22.3	27.3	24.8	23.1	49.1	57.8	11.3	38.2	8.9	0	42.2	0.104	0.0426	17.5	43.7	0.938
10/23/2001	11:20	0	27.1	22.3	27.4	24.8	23.1	49.7	58.5	11.0	38.8	9.0	0	41.6	0.104	0.0425	17.3	44.2	0.935
10/23/2001	11:21	0	27.2	22.3	27.5	24.8	23.1	49.7	58.6	11.0	39.2	9.0	0	41.7	0.104	0.0424	17.3	44.5	0.933
10/23/2001	11:22	0	27.2	22.3	27.6	24.8	23.1	49.3	58.1	10.9	38.9	9.0	0	41.5	0.104	0.0423	17.2	44.1	0.931
10/23/2001	11:23	0	27.4	22.4	27.6	24.7	23.0	49.8	58.6	11.0	39.2	9.0	0	41.5	0.103	0.0418	17.2	44.5	0.930
10/23/2001	11:24	0	27.4	22.4	27.7	24.6	23.0	49.6	58.3	10.9	39.1	9.0	0	41.8	0.103	0.0417	17.3	44.4	0.927
																Average	17.4	44.2	

Xflow2_102401_0630																			
Raw Data																Calculations			
DATE	TIME	Sol	FLTRT (°C) T2	CL LOOP (°C) T3	SL LOOP (°C) T1	UP AMB (°C) T4	BOT AMB (°C) T5	BOT DP (psid) dP2	FLTR (psig) P1	FLTR DP (psid) dP1	TOP DP (psig) dP3	FLT-RATE (psig) P2	BP (psig) P3	SL FLOW (gpm) Q1	FLTR FLOW (gpm) Q2	Temp corrected flow (gpm/ft^2)	Axial Vel (ft/sec)	Avg TMP (psid)	Temp corr factor
10/24/01	6:30	0	26.0	25.2	25.7	25.6	25.7	50.4	60.4	10.4	40.9	9.9	0	38.3	0.078	0.0334	15.9	45.6	0.980
10/24/01	6:31	0	26.0	25.2	25.7	25.6	25.8	50.8	60.9	10.4	41.0	9.9	0	38.4	0.077	0.0329	16.0	45.9	0.979
10/24/01	6:32	0	26.0	25.2	25.7	25.5	25.8	50.7	60.7	10.5	40.9	9.8	0	38.5	0.076	0.0325	16.0	45.8	0.980
10/24/01	6:33	0	26.0	25.3	25.8	25.6	25.8	51.0	61.0	10.6	41.0	9.8	0	38.4	0.076	0.0325	15.9	46.0	0.979
10/24/01	6:34	0	26.0	25.3	25.8	25.6	25.7	51.2	61.2	10.5	41.3	9.8	0	38.4	0.076	0.0324	15.9	46.3	0.978
10/24/01	6:35	0	26.0	25.3	25.8	25.6	25.7	50.7	60.6	10.4	40.9	9.8	0	38.5	0.075	0.0320	16.0	45.8	0.978
10/24/01	6:36	0	26.0	25.3	25.9	25.6	25.8	51.1	61.0	10.5	41.2	9.8	0	38.5	0.075	0.0320	16.0	46.1	0.976
10/24/01	6:37	0	26.1	25.3	25.8	25.6	25.8	51.0	60.8	10.5	40.9	9.7	0	38.4	0.075	0.0320	15.9	45.9	0.977
10/24/01	6:38	0	26.1	25.3	25.9	25.6	25.8	50.8	60.6	10.4	41.0	9.7	0	38.4	0.075	0.0319	15.9	45.9	0.975
10/24/01	6:39	0	26.1	25.3	25.8	25.6	25.8	51.0	60.7	10.4	41.2	9.7	0	38.4	0.074	0.0316	15.9	46.1	0.977
10/24/01	6:40	0	26.1	25.3	25.8	25.6	25.8	51.2	60.9	10.5	41.2	9.7	0	38.5	0.074	0.0316	16.0	46.2	0.977
10/24/01	6:41	0	26.1	25.3	25.9	25.6	25.7	51.1	60.9	10.5	41.1	9.7	0	38.4	0.074	0.0315	16.0	46.1	0.975
10/24/01	6:42	0	26.2	25.3	26.0	25.7	25.8	50.9	60.7	10.5	41.1	9.7	0	38.3	0.074	0.0315	15.9	46.0	0.974
10/24/01	6:43	0	26.2	25.3	26.0	25.6	25.8	51.3	61.0	10.5	41.0	9.7	0	38.2	0.074	0.0315	15.9	46.2	0.974
10/24/01	6:44	0	26.2	25.3	25.9	25.6	25.9	51.0	61.0	10.5	41.3	9.7	0	38.5	0.074	0.0315	16.0	46.2	0.974
10/24/01	6:45	0	26.2	25.3	26.0	25.6	25.8	51.0	60.8	10.5	41.3	9.7	0	38.5	0.074	0.0314	16.0	46.2	0.973
10/24/01	6:46	0	26.2	25.3	26.0	25.6	25.8	50.9	60.7	10.5	41.0	9.7	0	38.5	0.074	0.0314	16.0	45.9	0.973
10/24/01	6:47	0	26.3	25.4	26.0	25.6	25.8	50.9	60.6	10.4	41.1	9.7	0	38.4	0.073	0.0310	15.9	46.0	0.972
10/24/01	6:48	0	26.3	25.3	26.0	25.6	25.8	51.0	60.7	10.4	41.4	9.7	0	38.4	0.073	0.0310	15.9	46.2	0.973
10/24/01	6:49	0	26.3	25.3	26.0	25.6	25.8	51.2	60.8	10.5	41.1	9.7	0	38.5	0.073	0.0310	16.0	46.2	0.972
10/24/01	6:50	0	26.3	25.4	26.0	25.6	25.8	51.1	60.8	10.4	41.1	9.6	0	38.1	0.073	0.0310	15.8	46.1	0.972
10/24/01	6:51	0	26.3	25.4	26.0	25.6	25.8	51.3	61.0	10.5	41.4	9.6	0	38.4	0.073	0.0310	15.9	46.3	0.971
10/24/01	6:52	0	26.3	25.4	26.0	25.6	25.7	51.4	61.1	10.5	41.0	9.6	0	38.5	0.073	0.0310	16.0	46.2	0.972
10/24/01	6:53	0	26.3	25.4	26.1	25.6	25.8	51.2	60.9	10.5	41.3	9.6	0	38.4	0.073	0.0309	16.0	46.2	0.970
10/24/01	6:54	0	26.3	25.4	26.1	25.6	25.7	51.5	61.1	10.5	41.4	9.6	0	38.4	0.073	0.0309	15.9	46.4	0.970
10/24/01	6:55	0	26.3	25.4	26.1	25.6	25.8	51.2	60.8	10.5	41.2	9.6	0	38.4	0.073	0.0309	15.9	46.2	0.971
10/24/01	6:56	0	26.3	25.4	26.1	25.6	25.8	51.2	60.9	10.5	41.7	9.6	0	38.4	0.073	0.0309	15.9	46.5	0.970
10/24/01	6:57	0	26.4	25.4	26.1	25.6	25.8	51.4	61.1	10.5	41.3	9.6	0	38.4	0.073	0.0309	15.9	46.3	0.971
10/24/01	6:58	0	26.3	25.4	26.1	25.6	25.8	51.3	61.0	10.4	41.2	9.6	0	38.4	0.072	0.0305	15.9	46.3	0.969
10/24/01	6:59	0	26.4	25.4	26.1	25.6	25.8	51.0	60.5	10.5	41.1	9.6	0	38.4	0.072	0.0305	15.9	46.0	0.969
10/24/01	7:00	0	26.4	25.4	26.1	25.6	25.8	51.5	61.2	10.6	41.3	9.6	0	38.5	0.072	0.0304	16.0	46.4	0.968

Xflow2_102501_0700																			
Raw Data																Calculations			
DATE	TIME	Sol	FLTRT (°C) T2	CL LOOP (°C) T3	SL LOOP (°C) T1	UP AMB (°C) T4	BOT AMB (°C) T5	BOT DP (psid) dP2	FLTR (psig) P1	FLTR DP (psid) dP1	TOP DP (psig) dP3	FLTRATE (psig) P2	BP (psig) P3	SL FLOW (gpm) Q1	FLTR FLOW (gpm) Q2	Temp corr flow (gpm/ft^2)	Axial Vel (ft/sec)	Avg TMP (psid)	Temp corr factor
10/25/01	7:00	0	29.6	23.5	29.2	23.7	22.8	53.1	62.8	11.4	42.2	9.8	0	38.0	0.068	0.0264	15.8	47.6	0.889
10/25/01	7:01	0	29.5	23.5	29.2	23.7	22.7	53.2	63.0	11.4	42.4	9.7	0	38.0	0.068	0.0264	15.8	47.8	0.890
10/25/01	7:02	0	29.5	23.5	29.2	23.6	22.7	52.7	62.5	11.4	42.1	9.7	0	38.0	0.068	0.0264	15.8	47.4	0.890
10/25/01	7:03	0	29.5	23.5	29.3	23.6	22.6	53.1	62.9	11.3	42.4	9.7	0	38.0	0.068	0.0264	15.8	47.8	0.888
10/25/01	7:04	0	29.5	23.5	29.2	23.5	22.6	52.9	62.7	11.4	42.4	9.7	0	37.9	0.068	0.0264	15.7	47.6	0.890
10/25/01	7:05	0	29.5	23.5	29.3	23.5	22.6	52.8	62.4	11.4	42.3	9.7	0	38.0	0.068	0.0263	15.8	47.6	0.886
10/25/01	7:06	0	29.5	23.5	29.3	23.5	22.5	53.1	62.9	11.4	42.1	9.7	0	38.0	0.067	0.0259	15.8	47.6	0.887
10/25/01	7:07	0	29.5	23.5	29.3	23.4	22.5	52.9	62.7	11.4	41.9	9.7	0	37.9	0.068	0.0263	15.7	47.4	0.886
10/25/01	7:08	0	29.5	23.5	29.3	23.4	22.4	53.0	62.7	11.5	42.2	9.7	0	38.0	0.067	0.0260	15.8	47.6	0.887
10/25/01	7:09	0	29.5	23.5	29.4	23.4	22.4	52.8	62.6	11.4	42.3	9.7	0	37.9	0.068	0.0263	15.7	47.6	0.884
10/25/01	7:10	0	29.6	23.5	29.4	23.4	22.4	53.0	62.7	11.3	42.0	9.7	0	37.9	0.068	0.0263	15.7	47.5	0.884
10/25/01	7:11	0	29.6	23.5	29.5	23.4	22.3	53.1	62.8	11.3	42.2	9.7	0	37.9	0.068	0.0262	15.7	47.6	0.883
10/25/01	7:12	0	29.6	23.5	29.5	23.4	22.3	53.1	62.8	11.4	42.4	9.7	0	37.9	0.068	0.0262	15.7	47.7	0.882
10/25/01	7:13	0	29.6	23.5	29.5	23.3	22.2	52.8	62.6	11.4	42.3	9.7	0	37.8	0.068	0.0262	15.7	47.6	0.883
10/25/01	7:14	0	29.6	23.5	29.6	23.3	22.2	53.0	62.8	11.4	42.1	9.7	0	37.9	0.068	0.0262	15.7	47.6	0.881
10/25/01	7:15	0	29.7	23.5	29.5	23.3	22.2	52.7	62.4	11.3	42.3	9.7	0	37.8	0.068	0.0262	15.7	47.5	0.882
10/25/01	7:16	0	29.7	23.5	29.6	23.3	22.1	53.0	62.7	11.4	42.2	9.7	0	37.8	0.067	0.0258	15.7	47.6	0.881
10/25/01	7:17	0	29.7	23.4	29.7	23.2	22.1	53.1	62.9	11.3	42.3	9.7	0	37.8	0.068	0.0261	15.7	47.7	0.879
10/25/01	7:18	0	29.7	23.4	29.7	23.2	22.2	53.4	63.1	11.3	42.4	9.7	0	37.7	0.068	0.0261	15.6	47.9	0.879
10/25/01	7:19	0	29.8	23.4	29.7	23.2	22.2	53.0	62.9	11.3	42.6	9.7	0	37.7	0.068	0.0261	15.6	47.8	0.878
10/25/01	7:20	0	29.8	23.4	29.7	23.1	22.2	52.8	62.5	11.2	42.5	9.7	0	37.7	0.068	0.0260	15.6	47.7	0.877
10/25/01	7:21	0	29.8	23.4	29.7	23.1	22.2	53.4	63.2	11.3	42.4	9.7	0	37.7	0.067	0.0257	15.6	47.9	0.878
10/25/01	7:22	0	29.8	23.4	29.8	23.1	22.2	52.9	62.7	11.1	42.4	9.7	0	37.5	0.068	0.0260	15.6	47.7	0.875
10/25/01	7:23	0	29.9	23.4	29.8	23.2	22.2	53.0	62.7	11.3	42.7	9.7	0	37.7	0.067	0.0256	15.6	47.9	0.876
10/25/01	7:24	0	29.9	23.4	29.7	23.3	22.2	53.2	62.9	11.2	42.3	9.7	0	37.7	0.068	0.0261	15.6	47.7	0.878
10/25/01	7:25	0	29.9	23.4	29.6	23.2	22.3	53.2	62.9	11.3	42.9	9.7	0	37.7	0.068	0.0261	15.6	48.1	0.879
10/25/01	7:26	0	29.9	23.4	29.6	23.3	22.3	53.0	62.7	11.2	42.5	9.7	0	37.6	0.067	0.0257	15.6	47.7	0.880
10/25/01	7:27	0	29.8	23.4	29.6	23.3	22.3	52.9	62.6	11.1	42.4	9.7	0	37.6	0.067	0.0257	15.6	47.6	0.879
10/25/01	7:28	0	29.8	23.4	29.6	23.3	22.4	53.2	63.0	11.3	42.6	9.7	0	37.7	0.067	0.0257	15.6	47.9	0.880
10/25/01	7:29	0	29.8	23.4	29.6	23.3	22.4	53.3	63.1	11.3	42.5	9.7	0	37.7	0.067	0.0257	15.7	47.9	0.880
10/25/01	7:30	0	29.8	23.4	29.6	23.4	22.4	53.3	63.0	11.2	42.3	9.7	0	37.6	0.067	0.0258	15.6	47.8	0.881

Xflow2_110101_1045 (Deionized water after filtering Batch #2 and cleaning the filter)																				
Raw Data																	Calculations			
DATE	TIME	Sol	FLTRT (°C) T2	CL LOOP (°C) T3	SL LOOP (°C) T1	UP AMB (°C) T4	BOT AMB (°C) T5	BOT DP (psid) dP2	FLTR (psig) P1	FLTR DP (psid) dP1	TOP DP (psig) dP3	FLTRATE (psig) P2	BP (psig) P3	SL FLOW (gpm) Q1	FLTR FLOW (gpm) Q2	HI FLTR FLOW (gpm) Q3	Temp corr flow (gpm/ft^2)	Axial Vel (ft/sec)	Avg TMP (psid)	Temp corr factor
11/01/01	13:34	0	23.3	21.4	22.8	23.1	21.4	10.4	15.8	10.2	0.5	5.748	0	49.6	0.010	-0.019	0.0047	20.6	5.5	1.065
11/01/01	13:35	0	23.2	21.4	23.0	23.1	21.4	15.3	25.3	15.4	0.1	10.185	0	62.1	0.010	-0.019	0.0046	25.8	7.7	1.059
11/01/01	13:36	0	23.2	21.4	23.4	23.0	21.4	21.8	33.4	20.2	1.5	11.985	0	73.4	0.311	0.498	0.1420	30.4	11.7	1.045
11/01/01	13:37	0	23.4	21.4	23.9	23.0	21.3	21.7	33.6	20.3	2.0	12.103	0	73.2	0.286	0.302	0.1289	30.4	11.9	1.032
11/01/01	13:38	0	23.8	21.4	24.3	23.0	21.3	23.3	34.7	18.9	4.9	11.65	0	70.6	0.429	0.354	0.1911	29.3	14.1	1.020
11/01/01	13:39	0	24.5	21.4	24.7	22.9	21.3	31.2	43.8	10.5	20.7	12.911	0	52.4	1.211	1.580	0.5340	21.7	25.9	1.010
11/01/01	13:40	0	24.9	21.5	25.0	22.9	21.3	33.8	44.7	9.6	24.6	11.194	0	50.6	1.211	1.351	0.5291	21.0	29.2	1.000
11/01/01	13:41	0	25.2	21.5	25.3	22.9	21.3	36.4	44.9	9.8	26.8	8.773	0	50.6	1.211	1.246	0.5243	21.0	31.6	0.991
11/01/01	13:42	0	25.5	21.5	25.6	22.9	21.2	35.7	45.0	9.7	26.0	9.523	0	50.1	1.074	1.046	0.4609	20.8	30.9	0.983
11/01/01	13:43	0	25.8	21.5	25.9	22.9	21.2	29.1	44.6	9.7	20.0	15.879	0	50.7	1.211	1.537	0.5152	21.0	24.5	0.974
11/01/01	13:44	0	26.2	21.5	26.2	22.9	21.2	29.1	45.0	9.5	19.5	16.232	0	50.7	1.211	1.535	0.5108	21.0	24.3	0.966
11/01/01	13:45	0	26.5	21.5	26.6	22.9	21.2	33.0	44.9	9.3	23.7	12.228	0	50.3	1.211	1.398	0.5063	20.9	28.3	0.957
11/01/01	13:46	0	26.8	21.5	26.8	22.9	21.2	36.2	44.9	9.4	27.3	8.904	0	50.1	1.211	1.261	0.5024	20.8	31.8	0.950
11/01/01	13:47	0	27.0	21.5	27.2	22.9	21.2	37.5	44.8	9.5	28.7	7.654	0	50.2	1.123	1.090	0.4613	20.9	33.1	0.941
11/01/01	13:48	0	27.3	21.5	27.5	22.9	21.2	38.8	45.5	9.5	29.1	6.888	0	49.5	1.012	0.972	0.4124	20.5	33.9	0.933
11/01/01	13:49	0	27.6	21.5	27.8	22.9	21.2	39.3	44.8	9.4	30.3	5.938	0	50.2	0.926	0.894	0.3741	20.8	34.8	0.925
11/01/01	13:50	0	27.8	21.5	28.0	22.9	21.2	33.8	36.9	10.0	24.0	3.554	0	51.7	0.673	0.659	0.2700	21.4	28.9	0.919
11/01/01	13:51	0	28.0	21.5	28.3	23.0	21.3	34.0	36.9	9.5	24.5	3.265	0	50.1	0.638	0.604	0.2542	20.8	29.3	0.912
																		20.9	30.1	
11/01/01	13:52	0	28.4	21.5	28.5	23.0	21.3	32.4	34.9	9.6	22.8	2.82	0	50.5	0.583	0.553	0.2309	20.9	27.6	0.907
11/01/01	13:53	0	28.5	21.5	28.7	23.1	21.3	19.7	32.2	9.3	10.8	12.674	0	49.1	0.243	0.220	0.0956	20.4	15.3	0.901
11/01/01	13:54	0	28.6	21.5	28.9	23.1	21.4	20.5	30.4	9.8	11.1	10.236	0	50.9	0.290	0.277	0.1135	21.1	15.8	0.896
11/01/01	13:55	1	28.6	21.5	29.1	23.1	21.4	6.9	30.7	9.6	-2.8	23.969	74	49.6	0.214	0.111	0.0833	20.6	2.1	0.892
11/01/01	13:56	1	28.9	21.5	29.3	23.1	21.5	7.8	30.0	9.6	-1.6	22.676	74	49.8	0.014	-0.018	0.0054	20.7	3.1	0.887
11/01/01	13:57	0	29.3	21.5	29.5	23.2	21.6	22.0	30.2	9.6	12.5	8.532	0	51.3	1.131	1.063	0.4364	21.3	17.2	0.884
11/01/01	13:58	0	29.6	21.6	29.7	23.3	21.6	22.9	30.0	9.5	13.8	7.358	0	50.8	0.941	0.892	0.3610	21.1	18.4	0.878
11/01/01	13:59	0	29.7	21.5	29.9	23.3	21.6	24.0	30.1	9.7	14.9	6.387	0	50.6	0.787	0.745	0.3004	21.0	19.5	0.874
11/01/01	14:00	0	29.8	21.5	29.8	23.4	21.7	25.2	30.2	9.6	15.8	5.382	0	50.6	0.700	0.661	0.2679	21.0	20.5	0.876
11/01/01	14:01	0	29.8	21.5	29.4	23.6	21.8	26.0	30.3	9.7	16.6	4.6	0	50.3	0.622	0.605	0.2406	20.9	21.3	0.886
11/01/01	14:02	0	29.5	21.6	28.9	23.9	21.9	26.5	30.2	9.7	17.0	4.038	0	51.0	0.578	0.544	0.2265	21.2	21.8	0.898
11/01/01	14:03	0	29.3	21.6	28.3	24.2	22.0	11.4	20.4	9.5	2.2	9.225	0	49.8	0.120	0.090	0.0478	20.7	6.8	0.912
11/01/01	14:04	0	29.2	21.6	27.7	24.5	22.1	9.0	16.8	9.3	0.0	8.052	0	49.3	0.060	0.038	0.0243	20.4	4.5	0.928

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