Boildown Study on Supernatant Liquid Retrieved from AW-106 in December 2012

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EXECUTIVE SUMMARY

This document reports the results of a boildown study using a composite created from supernatant liquid grab samples retrieved from tank 241-AW-106 in December of 2012. The composite was made using predetermined volumes of the grab samples which accounted for layering of the supernatant liquid in the tank. The finished composite was a clear, yellow liquid containing no visible solids at hot cell ambient temperatures (24 - 27 °C). The density of the test composite was measured in the hot cell immediately before the boildown study and was 1.266 g/mL at 27.1 °C.

The boiling temperature of the composite was measured at three different pressures (40, 60, and 80 Torr) throughout the volume reduction, and the results show steadily increasing boiling temperatures with increasing volume reduction and no significant discontinuities. Moderate foaming was observed at the onset of the boildown. The foaming disappeared during the first reduction step, and minimal foaming was observed throughout the rest of the study.

The bulk densities at 18.0 °C ($D_{\text{Bulk}}^{18\text{ }^{\circ}\text{C}}$) and quantities of settled and centrifuged solids were measured on samples of the boildown concentrates. Estimated values of the bulk densities at the 60-Torr boiling temperatures ($D_{\text{Bulk}}^{60\text{ Torr}}$) were also calculated. The densities and solids content of concentrates at four levels of percent waste volume reduction (%WVR) were:

%WVR	34.7	39.3	44.1	48.7
$D_{\text{Bulk}}^{18\text{ }^{\circ}\text{C}}$ (measured)	1.400	1.424	1.457	1.495
$D_{\text{Bulk}}^{60\text{ Torr}}$ (estimated)	1.378	1.401	1.436	1.474
Vol% Settled Solids (18 °C)	0.0	2.2	51.3	47.8
Vol% Centrifuged Solids (18 °C)	1.5	3.2	25.3	31.5

Solids were first observed at boildown temperatures when the %WVR reached 39.3%. The quantity of solids in the composite quickly increased after this initial formation; the amount of centrifuged solids increased by 22% as the %WVR increased from 39.3 to 44.1%. A small amount of solids did appear in the samples collected prior to the initial formation during the boildown. These solids precipitated while they sat at hot cell ambient temperature and in the 18.0 °C water bath.

Analysis of boildown test samples indicated that natrophosphate ($\text{Na}_7\text{F}(\text{PO}_4)_2 \cdot 19\text{ H}_2\text{O}$) and kogarkoite (Na_3FSO_4) accounted for a majority of the initial solids (~80% of the dissolved sulfate and phosphate precipitated from the composite by 44.1 %WVR). The large increase in solids at 44.1 %WVR was dominated by sodium nitrate and sodium carbonate.

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LIST OF TERMS

Abbreviations and Acronyms

ATL	Advanced Technologies and Laboratories International, Inc.
AP-107	tank 241-AP-107
AW-106	tank 241-AW-106
C-Liq	centrifuged liquid
C-Sld(s)	centrifuged solid(s)
ChgBal	charge balance ratio
CON-#	step or sample number in boildown volume reduction
CP	initial test composite
CR	cumulative concentration ratio
CR °C	cumulative concentration ratio at indicated temperature
CR _{Model} °C	cumulative concentration ratio at indicated temperature calculated using additive volumes model
CR _{Step}	concentration ratio for a discrete step in a boildown test sequence
D	density
D _{Bulk}	bulk density (i.e. total density of a sample containing liquid and solids)
D _{Bulk} °C	bulk density at indicated temperature
D _{Bulk} 60 Torr	estimated bulk density at boiling temperature at 60 Torr
D _{Liq} °C	liquid density at indicated temperature
D _{Model} °C	density at indicated temperature calculated using additive volumes model
DIL-#	step or sample number in dilution of end-point slurry
IC	ion chromatography
ICP-AES	inductively coupled plasma-atomic emission spectrometry
Liq	liquid(s)
MDL	minimum detection limit
MDW	minimum detectable weight
NIST	National Institute of Standards and Technology
OmniLIMS	222-S Laboratory Information Management System
%-Rec	percent recovery
%WVR	percent waste volume reduction
%WVR °C	percent waste volume reduction at indicated temperature
%WVR _{Model} °C	percent waste volume reduction at indicated temperature calculated using additive volumes model
POC	point of contact
P _{Read}	pressure as read from transducer display
P _{Corrected}	corrected system pressure
P/T	combination measurement of boiling temperature at specified pressure
PLM	polarized light microscopy
RPD	relative percent difference
RTD	resistance temperature detector
SEI	secondary electron image

SEM/EDX	scanning electron microscopy with energy dispersive X-ray spectroscopy
Slds	solids
S-Sld(s)	settled solid(s)
SPC	solid phase characterization
T	temperature
T _{Read}	temperature as read from thermocouple display
T _{Corrected}	corrected system temperature
TIC	total inorganic carbon
TOC	total organic carbon
ΔTOC	reported TOC minus the sum of the carbon from reported concentrations of organic acid anions
Total C	total carbon
TSAP	Tank Sampling Analysis Plan
Vol	volume
Vol _{Read}	volume read from centrifuge cone volume scale
Vol _{Corrected}	corrected volume of sample in centrifuge cone
vol%	percent by volume
<i>f</i> _{Liq}	volume fraction of liquid in a sample
<i>f</i> _{Slds}	volume fraction of solids in a sample
Wt	weight
wt%	percent by weight
XRD	[powder] X-ray diffraction (or diffractometry)

Units

°C	degree(s) Celsius
cm	centimeter(s)
<i>g</i>	acceleration due to gravity (used to define relative centrifugal force)
g	grams
g/L	grams per liter
g/mL	grams per milliliter
kV	kilovolts
hr(s)	hour(s)
L	liter(s)
μm	micrometer
μg/mL	micrograms per milliliter
mL	milliliter
(ΔmL/mL)/Δ°C	change in milliliters per milliliter per change in degree Celsius (units of thermal expansion coefficient)
mm	millimeter
Torr	unit of pressure equivalent to 1 mm Hg

1 INTRODUCTION

A boildown study was conducted at the 222-S Laboratory on supernatant liquid retrieved from tank 241-AW-106 (AW-106) in December of 2012. This study characterized the behavior of a composite, created from multiple grab samples of the supernatant liquid, during volume reduction at the reduced pressures of 40, 60, and 80 Torr (mm Hg) as requested in the tank sampling and analysis plan (TSAP; RPP-PLAN-53006, *Tank 241-AW-106 Grab Sampling and Analysis Plan in Support of Evaporator Campaign for Fiscal Year 2013*) to support operations at the 242-A Evaporator. The boildown study was performed in hot cells 11A-5 and 11A-6 at the 222-S Laboratory in accordance with the customer-approved test plan (LAB-PLN-13-00001, *Test Plan for Boildown Study on Supernate Retrieved from 241-AW-106 in December 2012*). The operation of the boildown apparatus in hot cell 11A-6 was done in accordance with the Laboratory Technology Procedure ATS-LT-519-183, "222-S Laboratory Determination of Properties of Radiological Solutions as a Function of Volume Reduction at Reduced Pressure."

The boildown study was designed (1) to determine the relationship between solids formation and percent waste volume reduction (%WVR), (2) to determine the relationship between concentrate density and %WVR, (3) to determine the type and quantity of solids that may form in the AW-106 concentrates after cooling in the storage tanks at ambient temperatures, and (4) to define the relationship between boiling temperature and concentration of the composite sample. To obtain this information, the boildown study progressed through four stages:

Composite preparation	A composite of the AW-106 liquid waste was prepared from grab samples in proportion to the tank layering of the supernatant liquid.
Boildown concentration	Volume reduction of the AW-106 composite was performed at reduced pressures. Samples of the composite were withdrawn at sampling points defined by calculated, target densities of the concentrate.
End-point slurry dilution	The end-point slurry from the concentration sequence was diluted, in increments, reconstituting the composite to the early stages of the volume reduction.
Sample processing	Samples collected during the concentration and dilution sequences were processed and physicochemical analyses conducted.

2 PRELIMINARY OPERATIONS

2.1 PREPARATION OF TEST COMPOSITE

A composite of the AW-106 supernatant liquid grab samples was prepared volumetrically on February 11, 2013, as specified in the test plan and detailed in Table 2-1. Density values were reported for each grab sample by the 222-S Laboratory (RPP-RPT-54430, *Final Report for Tank 241-AW-106 Grab Samples in Support of Evaporator Campaign for Fiscal Year 2013*) and show the layering of the supernatant liquid in the tank. A small scattering of fine particulate on the bottom of the amber glass jar was observed in grab samples 6AW-12-03A, -04, and -04A. After consultation with the evaporator point of contact (POC), the particles were left in the jars and allowed to transfer into the composite. After composite creation, no appreciable solids were observed in the composite; the particulate either did not transfer or it dissolved in the solution. The final composite was a clear, yellow liquid containing no visible solids.

Table 2-1. Preparation of Tank 241-AW-106 Composite for Boildown Study.

Sample Number		Location	Density	Added to Composite		
Grab Sample	OmniLIMS ^a			g	mL	Vol%
6AW-12-01	S12T022783	Surface	—	—	—	—
6AW-12-02	S12T022785	≈1/6 of distance surface to solids	1.242	148.99	122.0	41.0
6AW-12-02A	S12T022787			126.05	103.5	
6AW-12-02DUP	S12T022797		1.237	—	—	
6AW-12-03	S12T022803	≈1/2 of distance surface to solids	1.244	193.61	158.5	41.0
6AW-12-03A	S12T022805			81.92	67.0	
6AW-12-04	S12T022815	≈5/6 of distance surface to solids	1.400	35.25	27.0	18.0
6AW-12-04A	S12T022817			97.98	72.0	
Composite	S13T001219	—	—	683.80	550.0	100.0

^a 222-S Laboratory Information Management System.

The density of the composite was measured in the 11A-6 hot cell as it was transferred to the glass pot in the boildown apparatus. The density measurement data is presented in Table 2-2. Three Class A, 100-mL volumetric flasks were filled with the composite liquid and weighed. The temperature of the composite liquid was 27.1 °C. The average density of the AW-106 composite was 1.266 ± 0.001 g/mL.

Table 2-2. Density of Tank 241-AW-106 Composite Measured in Hot Cell.

	Flask A	Flask B	Flask C
Reagent H₂O (not deaerated)			
Nominal flask volume (mL)	100 ± 0.08		
Wt reagent H ₂ O to fill flask (g)	99.528	99.593	99.554
Temperature of H ₂ O (°C)	24.0		
Reference H ₂ O density (g/mL)	0.997296		
Calculated H ₂ O density (g/mL)	.995	.996	.996
AW-106 Composite			
Wt composite to fill flask (g)	126.497	126.741	126.536
Calculated composite density (g/mL)	1.265	1.267	1.265
Temperature of composite (°C)	27.1		
Average composite density (g/mL)	1.266 ± 0.001 g/mL		
Density reported by 222-S (g/mL) ^a	1.250		

^a The temperature of the composite when the density was measured was not reported.

On February 12, 2013, approximately 13 mL of the composite (Sample CP) was transferred to a 15-mL centrifuge cone. To ensure that enough sample was available for chemical analysis of the composite, an additional 17 mL of the composite was placed in a glass vial and assigned sample number S13T001220. The cone was suspended in a water bath maintained at 18.0 °C for 5 days. No physical changes (specifically, no solids formation) were observed. The liquid in the cone was then transferred to a second sample vial and assigned sample number S13T001221.

2.2 FEED MIX TEST

On February 13, 2013, equal portions of the AW-106 composite and an archived grab sample from tank 241-AP-107 (AP-107) were combined. Consecutive boildowns were scheduled to be run on feeds from AP-107 and AW-106, and the feed mix test was requested to observe any physical changes, e.g., solids formation, gas generation, color change, temperature change, and clarity upon mixing. Approximately 20 mL of the AW-106 composite was placed in a glass vial, and ~20 mL of the AP-107 grab sample, 7AP-10-02A, was placed in a 50-mL centrifuged cone, Figure 2-1A. Both samples were clear and yellow with no visible solids, and the temperatures were 24.0 °C for the AW-106 sample and 24.2 °C for the AP-107 sample.

The AW-106 sample was then combined with the AP-107 sample in the centrifuge cone and gently swirled. There were no signs of gas evolution or solid formation, and the liquid remained clear, Figure 2-1B. The temperature of the solution was 24.1 °C indicating no exothermic or endothermic reactions occurred. After 6 days of periodic observations in the hot cell, there were no changes to the solution; it remained clear with no visible solids, Figure 2-1C.

Figure 2-1. Feed Mix Testing of Tank 241-AW-106 and Tank 241-AP-107 Supernatant Samples.

2.3 BOILDOWN APPARATUS

2.3.1 Temperature Sensor

A K-type thermocouple was used to measure the temperature of the composite in the boildown apparatus. The thermocouple signal was converted to a temperature readout (T_{Read}) using a Fisher¹ Model M107568 thermocouple reader. The T_{Read} values were changed to corrected temperatures ($T_{\text{Corrected}}$) using a calibration equation comparing the T_{Read} with ‘true’ temperatures measured with a National Institute of Standards and Technology (NIST) certified, platinum RTD digital thermometer (Ebro®² Electronic, Model TFX410-1/TPX100, Serial Number 15100653/15073983). Comparative temperature readings were made as initially cold reagent water in the boildown pot was slowly heated to boiling and then allowed to cool while being stirred gently. The resulting temperature calibration equation was:

$$T_{\text{Corrected}} \text{ } ^\circ\text{C} = (2.81 \times 10^{-6})(T_{\text{Read}})^3 - (7.16 \times 10^{-4})(T_{\text{Read}})^2 + (1.04)(T_{\text{Read}}) + 1.20 \quad (2-1)$$

2.4 PRESSURE SENSOR/CONTROLLER

The pressure within the boildown pot was read from a Cole-Parmer^{®3} Instrument Company, Model 68801-23 pressure reader/controller. A calibration equation was generated to change

¹ Thermo Fisher Scientific Inc., Waltham, Massachusetts.

² ebro® is a registered trademark of ebro Electronic GmbH & Co. KG, Ingolstadt, Fed Rep Germany.

³ Cole-Parmer® is a registered trademark of Cole-Parmer Instrument Company, Vernon Hills, Illinois.

pressure readings (P_{Read}) from the reader/controller to corrected pressures ($P_{\text{Corrected}}$). Sets of $T_{\text{Corrected}}$ and P_{Read} values were recorded as reagent water was boiled at pressures ranging from 24 to 98 Torr. The P_{Read} values were then compared with reference values for the vapor pressure of pure water at $T_{\text{Corrected}}$. The resulting pressure calibration equation was:

$$P_{\text{Corrected}} \text{ Torr} = (1.01)(P_{\text{Read}}) + 3.50 \quad (2-2)$$

2.4.1 Boildown Pot

The glass boildown pot used in this study has a maximum working volume of 500 mL and a minimum working volume of ~75 mL. The main portion of the pot is a flat-bottomed cylindrical vessel with an inner diameter of 7.9 cm and a height of 9.5 cm. There are three vertical, fin-like indentations protruding 6 mm into the interior of the pot which facilitate mixing of the pot contents when stirred by a magnetic stir bar. The upper portion of the pot is tapered (over 2.5 cm) to a cylindrical throat with an inner diameter of 5 cm. The top surface of the upper throat contains a groove for the O-ring joint by which the pot is connected to the rest of the boildown apparatus. Heating of the pot contents is accomplished by bringing a laboratory hotplate/magnetic stirrer into contact with the bottom of the pot.

2.4.2 Centrifuge Cones

The AW-106 boildown samples were initially collected in 15 mL, plastic centrifuge cones during the volume reduction and dilution sequences. The volume scales on the cones were used to estimate the quantities of solids present in the samples and to calculate bulk densities (D_{Bulk}). These cones are graduated in 0.5-mL increments from 1 to 14.5 mL and in 0.1-mL increments from 0 to 1 mL. The accuracy of the volume scales was checked by measuring the weight of reagent water required to fill the cones to the 10-, 12-, and 14-mL marks. The reference densities of water at the measurement temperatures were then used to calculate the actual volumes of water added. Duplicate measurements were performed for each cone. A linear function was derived for each cone relating the volume read from the cone gradations (Vol_{Read}) to the ‘actual’ volume ($\text{Vol}_{\text{Corrected}}$) contained. The gravimetric data, reference densities, calculations, and derived correction functions for each cone/boildown sample are presented in Attachment A.

3 TEST OPERATIONS AND RESULTS

3.1 HOT CELL TEST OPERATIONS

The basic operations performed and observations made during the boildown concentration, dilution, and sample processing stages are summarized in this section. Transcripts of the hot cell data logs that were used to control the boildown operations and perform the first data processing calculations are presented in Attachment B. Photographs of the samples at various times after being withdrawn from the pot during the boildown are presented in Attachment C.

3.1.1 Boildown Progress Parameters

Three parameters were used to monitor the progress of the boildown operations and in post-boildown data processing: concentration ratio (CR), percent waste volume reduction (%WVR), and concentrate bulk density (D_{Bulk}). The CR and %WVR are defined as

$$CR = \text{Vol}_{\text{Start}} / \text{Vol}_{\text{End}} \quad (3-1)$$

$$\%WVR = [(\text{Vol}_{\text{Start}} - \text{Vol}_{\text{End}}) / \text{Vol}_{\text{Start}}] \times 100 \quad (3-2)$$

The CR is the factor to which nonvolatile, infinitely soluble species become concentrated over their initial concentrations as the solution volume is reduced ($CR > 1$) or increased ($0 < CR < 1$).

Accurate measurement of the concentrate volume during a boildown run is very difficult. Even if this were not so, when multiple samples are withdrawn from the pot the concentrate volume during a boildown is no longer the appropriate value of Vol_{End} for calculation of CR or %WVR.

In practice, a boildown test is planned and controlled using an additive volumes model based on the following assumptions: (1) all solutes are nonvolatile (i.e., only water is removed from the test system), (2) the quantities of all additions to or removals from the system are accurately measured, (3) the volumes of all system components are measured at a common temperature, and (4) the volumes of system components are additive (i.e., $\text{Vol}_{\text{Start}} = \text{Vol}_{\text{End}} \pm \text{Vol}_{\text{H}_2\text{O}}$). Using this model, boildown progress is calculated stepwise. For each step N

$$\text{Vol}_{\text{Start Step } N} = \text{Vol}_{\text{End Step } N-1} - \text{Vol}_{\text{Sample } N}, \text{ and} \quad (3-3)$$

$$CR_{\text{Step } N} = \text{Vol}_{\text{Start Step } N} / (\text{Vol}_{\text{Start Step } N} \pm \text{Vol}_{\text{H}_2\text{O}}) \quad (3-4)$$

The cumulative CR based on the additive volumes model, CR_{Model} , is

$$CR_{\text{Model}} = CR_{\text{Step } 1} \times CR_{\text{Step } 2} \times CR_{\text{Step } 3} \times \dots \times CR_{\text{Step } N} \quad (3-5)$$

and

$$\%WVR_{\text{Model}} = [(CR_{\text{Model}} - 1) / CR_{\text{Model}}] \times 100 \quad (3-6)$$

In the additive volumes model, the bulk density of the concentrate, D_{Model} , is a linear function of CR :

$$D_{\text{Model}} = [(D_{\text{AW-106 Composite}} - D_{\text{H}_2\text{O}}) \times CR_{\text{Model}}] + D_{\text{H}_2\text{O}} \quad (3-7)$$

The density of the AW-106 test composite was measured in the 11A-6 hot cell (Table 2-2) and found to be 1.266 g/mL at 27.1 °C. This value was used to convert the starting weight of the test composite to a volume. The weights of water removed/added during the boildown were converted to volumes by dividing by the reference density of water at 27.1 °C. The weights of samples removed from the pot were converted to volumes by dividing by the $D_{\text{Model}}^{27.1\text{ }^{\circ}\text{C}}$ values calculated in the spreadsheet log. The resulting values of $CR_{\text{Model}}^{27.1\text{ }^{\circ}\text{C}}$ and $\%WVR_{\text{Model}}^{27.1\text{ }^{\circ}\text{C}}$ are shown in the boildown log in Table B-1.

3.1.2 Boildown Test Log

The following is a chronological log of the AW-106 boildown study, annotated with key observations and descriptions. Where pressures are cited only as integral values, they refer to the nominal target reflux pressures of 40, 60, or 80 Torr, not actual P_{Read} or $P_{\text{Corrected}}$ values.

The boildown concentration and dilution steps were performed in the 11A-6 hot cell; sample processing was performed in the adjacent 11A-5 hot cell. Typical ambient temperatures in the hot cells were 24 to 27 °C. All test samples were collected in disposable plastic 15-mL centrifuge cones (Section 2.2.4) and processed in these cones through the final separation into centrifuged liquid (C-Liq) and centrifuged solids (C-Slds) fractions.

Boildown Composite Preparation—February 11, 2013

08:30 The AW-106 boildown test composite was prepared volumetrically, as specified by the 242-A Evaporator POC, using 6 of the 8 grab samples received at the 222-S Laboratory (Section 2.1). A small scattering of fine particulate on the bottom of the amber glass jar was observed in grab samples 6AW-12-03A, -04, and -04A. After consultation with the Evaporator POC, the particles were left in the jars and allowed to transfer into the composite. After composite creation, no appreciable solids were observed in the composite; the particulate either did not transfer or it dissolved in the solution. The final composite was a clear, yellow liquid containing no visible solids.

A 30-mL sample was withdrawn from the composite for analysis, Sample CP. Approximately 13 mL of the sample was transferred to a 15-mL centrifuge cone and placed in an 18.0 °C water bath. The remaining 17 mL was transferred to a labeled sample vial and set aside.

A 20 mL sample of the composite was also withdrawn and placed in a labeled sample vial, which was set aside for use in a feed mix test with an AP-107 archived sample.

Feed Mix Test—February 13, 2013

09:20 The 20-mL composite sample withdrawn on 2/11/13 was combined with a 20-mL archived grab sample from AP-107 in a 50-mL centrifuge cone (Section 2.2). After the mixing, there were no signs of gas evolution, solid formation, or temperature change, and the liquid remained clear.

Boildown Volume Reduction Sequence—February 20, 2013

- 08:15 The prepared AW-106 composite, 618.119 g, was transferred to the boildown pot using 100 mL volumetric flasks. The density of the composite was measured during the transfer (Section 2.1) and determined to be 1.266 g/mL at 27.1 °C. The calculated initial volume of the composite test sample was 488.3 mL.
- 10:40 Boiling pressure/temperature (P/T) measurements on the composite were completed at 40, 60, and 80 Torr. Boiling was gentle and well behaved. Foam, made of large bubbles, formed in the pot and rose to the bottom of the condensing column (Figure 3-1A). The test composite was a clear, yellow liquid with no visible solids.
- 11:10 Concentration at 40 Torr was begun (CON-1a). On completion at 12:32, 37.4 mL of water was removed: 7.66 %WVR_{Model}^{27.1 °C}. P/T measurements at 40, 60, and 80 Torr were completed at 12:50. Boiling was gentle, producing easily broken large bubbles. Composite was a clear, medium yellow liquid with no visible solids.
- 13:02 Concentration at 40 Torr was begun (CON-1b). On completion at 13:45, 39.4 mL of water was removed: 15.73 %WVR_{Model}^{27.1 °C}. P/T measurements at 40, 60, and 80 Torr were completed at 14:04. Boiling was gentle and well behaved with quickly popping bubbles (Figure 3-1B). Composite was a clear, yellow liquid with no visible solids.

Figure 3-1. Tank 241-AW-106 Composite during the Early Stages of the Volume Reduction.

- 14:20 Sample CON-1 was drawn from the pot (12.5 mL) and transferred to Centrifuge Cone 8. A photograph of the sample was taken after the pot was reconnected to the still head.

14:30 Boildown was halted. The heat to the boildown pot was turned off, the pot was vented to hot cell ambient pressure, and the magnetic stirrer was left on.

Boildown Volume Reduction Sequence—February 21, 2013

- 07:30 Overnight at hot cell ambient pressure and temperature (26.4 °C), the test composite became cloudy and was partially opaque (Figure 3-1C).
- 07:53 Composite reflux established at 40 Torr (38.0 °C). The cloudiness disappeared and the solution became clear. Boiling was well behaved with no visible solids (Figure 3-1D).
- 07:56 Concentration at 40 Torr was begun (CON-2). On completion at 08:25, 37.7 mL of water was removed: 23.69 %WVR_{Model}^{27.1 °C}. P/T measurements at 40, 60, and 80 Torr were completed at 08:39. Boiling was steady, gentle, and well behaved with large bubbles breaking at a single layer (Figure 3-2A). The liquid was medium yellow with no visible solids.
- 08:50 Sample CON-2 was drawn from the pot (12.5 mL) and transferred to Centrifuge Cone 11. A photograph of the sample was taken after the pot was reconnected to the still head.
- 09:12 Concentration at 40 Torr was begun (CON-3). On completion at 10:02, 26.7 mL of water was removed: 29.53 %WVR_{Model}^{27.1 °C}. P/T measurements at 40, 60, and 80 Torr were completed at 10:15. Boiling was steady and gentle, no foaming, with a single layer of popping bubbles. The liquid was medium yellow with no visible solids (Figure 3-2B).

Figure 3-2. Tank 241-AW-106 Composite during Mid Stages of the Volume Reduction.

- 10:27 Sample CON-3 was drawn from the pot (12.5 mL) and transferred to Centrifuge Cone 3. A photograph of the sample was taken after the pot was reconnected to the still head.
- 10:45 Concentration at 40 Torr was begun (CON-4). On completion at 11:16, 25.5 mL of water was removed: 35.32 %WVR_{Model}^{27.1 °C}. P/T measurements at 40, 60, and 80 Torr were completed at 11:24. Boiling was steady and gentle with larger, quickly popping bubbles one layer thick. The liquid was medium yellow with no visible solids (Figure 3-2C).
- 11:37 Sample CON-4 was drawn from the pot (12.4 mL) and transferred to Centrifuge Cone 4. A photograph of the sample was taken after the pot was reconnected to the still head.
- 11:54 Concentration at 40 Torr was begun (CON-5). After 16.9 mL of water was removed (12:15), the composite become cloudy as solids began to form (Figure 3-2D). The concentration step was interrupted and P/T measurements taken. Solids remained for all three measurements, and the concentration step was restarted. On completion at 12:30, 21.4 mL of water was removed: 40.42 %WVR_{Model}^{27.1 °C}. P/T measurements at 40, 60, and 80 Torr were completed at 12:38. Boiling was well behaved with a single layer of bubbles. The liquid was very cloudy and yellow (Figure 3-3A).
- 12:47 Sample CON-5 was drawn from the pot (12.3 mL) and transferred to Centrifuge Cone 5. A photograph of the sample was taken after the pot was reconnected to the still head.
- 13:04 Concentration at 40 Torr was begun (CON-6). On completion at 13:18, 19.5 mL of water was removed: 45.31 %WVR_{Model}^{27.1 °C}. P/T measurements at 40, 60, and 80 Torr were completed at 13:25. Boiling was steady, well behaved, and without foaming. The composite was completely opaque, and the loading of fine, white solids in the slurry was noticeably greater (Figure 3-3B).

Figure 3-3. Tank 241-AW-106 Composite During the End Stages of the Volume Reduction.

- 13:36 Sample CON-6 was drawn from the pot (12.4 mL) and transferred to Centrifuge Cone 14. A photograph of the sample was taken after the pot was reconnected to the still head.
- 13:57 Concentration at 80 Torr was begun (CON-7). On completion at 14:08, 18.1 mL of water was removed: 50.10 %WVR_{Model}^{27.1 °C}. P/T measurements at 40, 60, and 80 Torr were completed at 14:13. This was the end-point of the boildown concentration. The test composite was a thick, milky, yellow slurry of fine, white solids (Figure 3-3C).
- 14:23 Sample CON-7 was drawn from the pot (12.4 mL) and transferred to Centrifuge Cone 13. A photograph of the sample was taken after the pot was reconnected to the still head.

End-point Slurry Dilution Sequence—February 21, 2013

- 14:50 Dilution step DIL-1 was completed by adding 52.8 mL of water back to the pot: 35.10 %WVR_{Model}^{27.1 °C}. Reflux of the test slurry at 60 Torr was established and a P/T measurement completed at 15:00. Boiling was well behaved with no foaming. The concentration of solids was visibly reduced but the test slurry remained cloudy (Figure 3-4A).
- 15:06 Sample DIL-1 was drawn from the pot (12.3 mL) and transferred to Centrifuge Cone 15. A photograph of the sample was taken after the pot was reconnected to the still head.
- 15:26 Dilution step DIL-2 was completed by adding 35.3 mL of water back to the pot: 24.49 %WVR_{Model}^{27.1 °C}. Reflux of the test slurry at 60 Torr was established, and a P/T measurement was completed at 15:38. Boiling was well behaved with no foaming. The composite remained cloudy (Figure 3-4B).
- 16:00 Sample DIL-2 was drawn from the pot (12.5 mL) and transferred to Centrifuge Cone 10. A photograph of the sample was taken after the pot was reconnected to the still head.

Figure 3-4. Tank 241-AW-106 Composite during the Volume Dilution.

- 16:10 Dilution step DIL-3 was completed by adding 46.8 mL of water back to the pot: 9.71 %WVR_{Model}^{27.1 °C}. Reflux of the test slurry at 60 Torr was established, and a P/T measurement was completed at 16:23. Boiling was well behaved with no foaming. The test slurry was partially cloudy (Figure 3-4C).
- 16:33 Sample DIL-3 was drawn from the pot (12.6 mL) and transferred to Centrifuge Cone 2. A photograph of the sample was taken after the pot was reconnected to the still head.
- 16:34 Boildown was terminated. The reconstituted composite was transferred to a glass jar for temporary storage. The weight of the remaining composite was 341.82 g.

3.2 HOT CELL SAMPLE PROCESSING

3.2.1 Initial Sample Processing

February 22, 2013: The boildown samples were transferred to Hot Cell 11A-5. By the morning of this day, Sample CON-1 had been sitting at hot cell ambient temperature for 42 hrs, and Samples CON-2 through CON-7 and DIL-1 through DIL-3 had been sitting for 18-24 hrs. All 10 cones were weighed and photographed (Attachment C). The total sample volume and the estimated volume of any settled solids (S-Slds) were recorded for each sample.

All 10 sample cones and the jar containing the final slurry recovered from the boildown pot were suspended in a water bath cooled to 18.0 °C.

February 27, 2013: Starting at 10:12, each boildown sample was removed from the 18.0 °C water bath and photographed (Attachment C). The total sample volume, S-Slds volume, and visual appearance of the S-Slds were recorded for each sample. The samples were then returned to the water bath.

The appearance and settling behavior observed in boildown Samples CON-1 through CON-7 and DIL-1 through DIL-3 are summarized in Table 3-1. Descriptions of the samples shortly after removal from the pot, after at least 18 hrs at hot cell ambient temperature and after ~ 5 days at 18.0 °C, are included.

3.2.2 Final Sample Processing

February 27, 2013: Starting at 13:30, the boildown samples were removed from the 18.0 °C water bath and centrifuged for 10 minutes at ~1000 × g. The samples were then returned to the water bath. Photos were taken (Attachment C).

Table 3-1. Appearance of Settled Solids in Boildown Samples. (2 sheets)

Sample	%WVR	Appearance of Settled Solids
CON-1	15.7	<p><1 hr after sampling: The pot sample was a clear, yellow liquid with no visible solids.</p> <p>42 hrs at 24.4 °C: The sample was a clear, yellow liquid with no settled solids. Some small solids were attached to the cone wall.</p> <p>5 days at 18 °C: The sample was a clear, yellow liquid with no settled solids. Some small solids were attached to the cone wall.</p>
CON-2	23.7	<p><1 hr after sampling: The pot sample was a clear, yellow liquid with no visible solids.</p> <p>24 hrs at 24.4 °C: The sample was a clear, yellow liquid with no settled solids. Some small, granular solids were attached to the lower cone wall.</p> <p>5 days at 18 °C: The sample was a clear, yellow liquid with no settled solids. Some small, granular solids were attached to the lower cone wall.</p>
CON-3	29.5	<p><1 hr after sampling: The pot sample was a clear, yellow liquid with no visible solids.</p> <p>23 hrs at 24.4 °C: The sample was a clear, yellow liquid with no settled solids. Small, clear, granular solids were attached to the lower cone wall.</p> <p>5 days at 18 °C: The sample was a clear, yellow liquid with no settled solids. Small, clear, granular solids were attached to the cone wall with a greater number near the bottom of the cone.</p>
CON-4	35.3	<p><1 hr after sampling: The pot sample was a clear, yellow liquid with no visible solids.</p> <p>22 hrs at 24.4 °C: The sample was a clear, yellow liquid with a trace of settled solids. There was a continuous layer of clear, granular particles adhered to the lower half of the cone wall.</p> <p>5 days at 18 °C: The sample was a clear, yellow liquid with a trace of settled solids. There was a continuous layer of clear, granular particles adhered to the lower half of the cone wall.</p>
CON-5	40.4	<p><1 hr after sampling: The pot sample was a cloudy, yellow liquid with some settled, fine solids filling ~0.1 mL of the bottom of the cone.</p> <p>21 hrs at 24.4 °C: The sample was a clear, yellow liquid with some settled, fine solids filling ~0.2 mL of the bottom of the cone.</p> <p>5 days at 18 °C: The sample was a clear, yellow liquid with some settled, fine solids. No significant change in the appearance of the S-Slds. Particles in the S-Slds were too small to observe any morphology.</p>
CON-6	45.3	<p><1 hr after sampling: The pot sample was a cloudy, yellow liquid with flocculent solids filling ~9 mL of the cone.</p> <p>20 hrs at 24.4 °C: The sample was a clear, yellow liquid with flocculent solids filling ~6 mL of the cone.</p> <p>5 days at 18 °C: No significant change in the appearance of the S-Slds. Particles in the S-Slds were too small to observe any morphology.</p>
CON-7	50.1	<p><1 hr after sampling: This was the end-point slurry sample. The cone was completely filled with suspended solids.</p> <p>20 hrs at 24.4 °C: The sample was a clear, yellow liquid with fine solids filling ~6 mL of the cone. One large pyramidal crystal on cone wall.</p> <p>5 days at 18 °C: No significant change in the appearance of the S-Slds. Particles in the S-Slds were too small to observe any morphology.</p>

Table 3-1. Appearance of Settled Solids in Boildown Samples. (2 sheets)

Sample	%WVR	Appearance of Settled Solids
DIL-1	35.1	<p><1 hr after sampling: The pot sample was a cloudy, yellow liquid with some settled, fine solids filling <0.1 mL of the bottom of the cone.</p> <p>19 hrs at 24.4 °C: The sample was a clear, yellow liquid with some settled, fine solids filling ~1.5 mL of the bottom of the cone.</p> <p>5 days at 18 °C: There was no significant change in the appearance of the S-Slds. Particles in the S-Slds were too small to observe any morphology. Some additional granular solids on cone wall.</p>
DIL-2	24.5	<p><1 hr after sampling: The pot sample was a clear, yellow liquid with flocculent solids filling ~2 mL of the cone.</p> <p>18 hrs at 24.4 °C: The sample was a clear, yellow liquid with some settled, fine solids filling ~1 mL of the bottom of the cone.</p> <p>5 days at 18 °C: There was no significant change in the appearance of the S-Slds. Particles in the S-Slds were too small to observe any morphology. Some additional solids on cone wall.</p>
DIL-3	9.7	<p><1 hr after sampling: The pot sample was slightly cloudy with no settled solids.</p> <p>18 hrs at 24.4 °C: The sample was a clear, yellow liquid with some settled, fine solids filling ~0.5 mL of the bottom of the cone.</p> <p>5 days at 18 °C: There was no significant change in the appearance of the S-Slds. Particles in the S-Slds were too small to observe any morphology. Some additional solids were on the cone wall.</p>

March 4, 2013: Boildown Samples CON-1 through CON-7 and DIL-1 through DIL-3 were removed from the 18.0 °C water bath, centrifuged for 10 minutes at ~1000 × g, and then returned to the bath. After all 10 samples had been through the second centrifuge cycle, they were photographed.

Densities of the C-Liq were measured by transferring 1.0 mL aliquots to a tared glass vial via a positive displacement pipette. The liquid was then returned to the centrifuge cone, and the cone placed back into the 18.0 °C water bath.

March 5, 2013: The centrifuged supernatant liquid C-Liq was decanted into labeled sample vials for all of the 10 samples. The C-Slds were then collected for solid phase characterization (SPC).

Due to the small quantities of C-Slds present, the solids recovered from samples CON-3 through CON-5 were combined. A small quantity of C-Liq from Sample CON-5 was used to facilitate recovery and transfer of the C-Slds to a sample vial.

The C-Slds from Sample CON-6 were recovered and transferred to a sample vial.

The C-Slds from Sample CON-7 were recovered and transferred to a sample vial. Due to the compacted nature of the solids, some C-Liq from CON-7 was used to transfer the solids.

Due to the limited amount of C-Slds in Sample DIL-3, the solids from step DIL-3 were collected from the S-Slds in the bottom of the jar containing the final slurry set aside at the conclusion of the boildown test.

The final identifications of the AW-106 boildown study samples are tabulated in Table 3-2.

Table 3-2. Identification of Tank 241-AW-106 Boildown Samples.

Test Sample	222-S Sample Number S13T00-	
	Liquid	Solids
Test Composite		
CP	-1220	—
	-1221	
Volume Reduction		
CON-1	-1234	—
CON-2	-1235	—
CON-3	-1236	-1244
CON-4	-1237	
CON-5	-1238	
CON-6	-1239	-1245
CON-7	-1242	-1246
Dilution of End-point Slurry		
DIL-1	-1251	—
DIL-2	-1252	—
DIL-3	-1253	-1254

March 8, 2013: The 12 samples of boildown liquids were loaded out of the 11A hot cells and submitted to 222-S Laboratory for analysis. The 4 samples of boildown sample solids were loaded out and submitted for SPC measurements.

3.2.3 Densities of Boildown Sample Liquids

The densities of the boildown C-Liq samples were measured before the samples were loaded out of the hot cells and submitted to the 222-S Laboratory for analysis. To perform the measurements, the temperature of the C-Liq samples were first measured (the temperatures of the samples were 18.0 °C due to the use of the water bath). Using a positive-displacement pipette, a 1.00-mL portion of each liquid was transferred to a sample vial and weighed. A second 1.00 mL-sample portion was then added to the vial and weighed. The average C-Liq density was calculated. The test liquid was then returned to the parent sample using a disposable pipette.

The density of demineralized water (24.2 °C) was measured before and after the C-Liq sample measurements. All the measured densities were within 1% of the reference values for pure water.

3.3 FINAL VOLUME AND WEIGHT DATA

The results of gravimetric and volumetric measurements on the boildown samples are summarized in Table 3-3.

The total S-Slds and C-Slds volumes at hot cell ambient temperature (24.4 °C) and at 18.0 °C are based on examination of sample photographs. Apparent volumes (Vol_{Read}) were measured as accurately as possible from enlargements of sample photographs. The Vol_{Read} values were then converted to $Vol_{Corrected}$ volumes using the cone calibration functions in Attachment A.

The vol% S-Slds and vol% C-Slds in each sample are the apparent volumes of the solids divided by the corrected total volumes at 18.0 °C or at hot cell ambient temperature with the results multiplied by 100.

The D_{Bulk} values are the weights of the bulk samples divided by the total sample volumes measured at the indicated temperature.

The $D_{Liq}^{18\text{ }^{\circ}\text{C}}$ measurement values in Table 3-3 are the results of densities measurements of the C-Liq portions of the boildown samples as discussed in Section 3.2.3. Each $D_{Liq}^{18\text{ }^{\circ}\text{C}}$ calculation value is the weight of the C-Liq decanted from a sample divided by the estimated difference between the total and C-Slds volumes while still in the 15-mL centrifuge cone at 18.0 °C. The $D_{Liq}^{222\text{-S}}$ values are the densities of the C-Liq samples measured by the 222-S Laboratory personnel.

Table 3-3. Gravimetric and Volumetric Data for Tank 241-AW-106 Boildown Samples.

Test Sample	CP	CON 1	CON 2	CON 3	CON 4	CON 5	CON 6	CON 7	DIL 1	DIL 2	DIL 3
%WVR ^{18 °C a}	0.0	15.5	23.3	29.0	34.7	39.3	44.1	48.7	34.4	24.1	10.0
CR ^{18 °C a}	1.00	1.18	1.30	1.41	1.53	1.65	1.79	1.95	1.52	1.32	1.11
Total Wt (g)	16.275	16.466	16.856	17.207	17.552	17.882	18.466	19.006	17.386	16.951	16.308
Wt Wet 18 °C C-Slds (g)	0.000	0.151	0.186	0.260	0.352	1.167	5.071	6.370	0.981	0.668	0.213
Wt 18 °C C-Liq (g)	16.275	16.315	16.670	16.947	17.200	16.715	13.395	12.636	16.405	16.283	16.095
Total Vol ^{Ambient} (mL)	12.80	12.55	12.57	12.61	12.56	12.54	12.73	12.78	12.44	12.52	12.49
Vol ^{Ambient} S-Slds (mL)	0.00	0.00	0.00	0.00	0.00	0.25	6.50	6.20	1.50	1.20	0.45
Total Vol ^{18 °C} (mL)	12.85	12.54	12.55	12.57	12.54	12.56	12.67	12.71	12.44	12.59	12.55
Vol ^{18 °C} S-Slds (mL)	0.00	0.00	0.00	0.00	0.00	0.28	6.50	6.10	1.50	1.20	0.40
Vol ^{18 °C} C-Slds (mL)	0.00	0.07	0.10	0.15	0.19	0.40	3.20	4.00	0.55	0.32	0.10
Vol ^{18 °C} C-Liq (mL)	12.85	12.47	12.45	12.42	12.35	12.16	9.47	8.71	11.89	12.27	12.45
Vol% S-Slds at Ambient T	0.00	0.00	0.00	0.00	0.00	1.99	51.06	48.51	12.06	9.58	3.60
Vol% S-Slds at 18 °C	0.00	0.00	0.00	0.00	0.00	2.23	51.30	47.99	12.06	9.53	3.19
Vol% C-Slds at 18 °C	0.00	0.56	0.80	1.19	1.52	3.18	25.26	31.47	4.42	2.54	0.80
Wt% Wet 18 °C C-Slds	0.000	0.917	1.103	1.511	2.005	6.526	27.461	33.516	5.642	3.941	1.306
D _{Bulk} ^{18 °C} (g/mL)	1.267	1.313	1.343	1.369	1.400	1.424	1.457	1.495	1.398	1.346	1.299
D _{Liq} ^{18 °C} (g/mL) measured	1.267	1.318	1.348	1.371	1.400	1.421	1.427	1.431	1.393	1.349	1.303
D _{Liq} ^{18 °C} (g/mL) calculated	1.267	1.308	1.339	1.364	1.393	1.375	1.414	1.451	1.380	1.327	1.293
D _{Liq} ^{222-S} (g/mL)	1.250	1.291	1.317	1.336	1.356	1.392	1.366	1.380	1.347	1.313	1.368

CP = initial test composite

^a Actual test values of boildown progress parameters as calculated in Section 5.1.2.

The $D_{\text{Liq}}^{18^\circ\text{C}}$ measurement values and the density values reported by the 222-S Laboratory are presented graphically in Figure 3-5. In this figure, and all other plots in this report, values for the initial test composite (CP) and the volume reduction sequence samples (CON-1 to CON-7) are displayed with solid data markers; values for the dilution sequence samples (DIL-1 to DIL-3) are displayed with hollow data markers of the same shape and border color.

The plots of the $D_{\text{Liq}}^{18^\circ\text{C}}$ and $D_{\text{Liq}}^{222\text{-S}}$ values both display similar trends: an increasing density which begins to plateau when solids formed in the composite. The values reported by the 222-S Laboratory have a lower density. This could be a systematic error (the temperature of the 222-S Laboratory data were not recorded). In contrast, the $D_{\text{Liq}}^{18^\circ\text{C}}$ values follow the trend line well, were all acquired at the reported temperature, and do not have any outliers suggesting that they better represent the actual densities of the C-Liq in the samples.

Figure 3-5. Density of Sample Liquids versus Tank 241-AW-106 Boildown Progress.

4 LABORATORY ANALYSIS OF BOILDOWN SAMPLES

The liquid samples created during the AW-106 boildown were submitted to the 222-S Laboratory for chemical analysis. These analyses were performed by the 222-S analytical contractor, Advanced Technologies and Laboratories International, Inc. (ATL). A transcript of the analysis results is presented in Attachment D.

The analysis results are summarized in Table 4-1. Analysis results for all priority analytes are presented. Other (opportunistic) analytes for which none of the analysis results exceeded the reported detection limit have been omitted from the table.

The sum of the total organic carbon (TOC) and total inorganic carbon (TIC) analysis results compares well (<2% error) to all three measurements of the total carbon (Total C) confirming the accuracy of these measurements.

The concentrations of four organic acid anions—formate, acetate, glycolate, and oxalate—in the sample liquids were analyzed by ion chromatography (IC). The concentrations of organic carbon represented by the reported concentrations of the anions were calculated and subtracted from the reported TOC values measured by acid sparging/persulfate oxidation/coulometry. The differences are tabulated as Δ TOC. The reported TOC is 42-71% greater than the sum of the carbon from the organic acid anions. Although this unaccounted organic carbon was also similarly observed in the previous AP-107 boildown (LAB-RPT-12-00008), the cause for this discrepancy is unknown although it is likely that other organic compounds are in the waste.

The oxalate concentration drops below the quantitative detection limit for the CON-5 sample (where solids first formed) suggesting that oxalate precipitated from solution and did not go back into solution during the dilution sequence.

The concentrations of phosphate (PO_4^{3-}) in the liquid samples measured with IC fell below the detection limit for all samples except for CP and DIL-3. However, the phosphate number was captured by using the reported concentrations of P, measured with inductively coupled plasma-atomic emission spectrometry (ICP-AES), and then recalculated as PO_4^{3-} . The calculated PO_4^{3-} trend also shows that the highest concentrations were in the CP and DIL-3 samples similar to the two measured PO_4^{3-} concentrations.

The concentrations of sulfate (SO_4^{2-}) in the liquid samples measured with IC can be compared with concentrations of S measured with ICP-AES and then recalculated as SO_4^{2-} . The calculated ICP-AES SO_4^{2-} values correspond rather well with the measured sulfate (<10%) for all samples except CON-7, DIL-1, and DIL-2 (15 to 20%).

The ratio of the total, calculated positive charge to the total, calculated negative charge, referred to as a charge balance calculation, is shown in the last row of the table and serves as a quality check of the chemical results. Values from 0.90 to 1.05 are generally considered acceptable.

Table 4-1. Results of Analyses of Tank 241-AW-106 Boildown Sample Liquids. (2 sheets)

(All analysis results in units of µg/mL)

Test Sample	CP	CON-1	CON-2	CON-3	CON-4	CON-5	CON-6	CON-7	DIL-1	DIL-2	DIL-3
%WVR ^{18°C}	0.00	15.49	23.28	28.99	34.67	39.35	44.09	48.71	34.42	24.07	9.98
Total C	7,780	—	—	—	—	—	12,600	—	—	—	8,910
TOC	1,340	1,600	1,870	1,930	2,260	1,970	2,060	2,500	1,900	1,580	1,440
ΔTOC ^a	681	461	609	658	781	803	721	935	1,102	579	741
TIC	6,330	7,600	8,640	9,330	10,600	11,100	8,980	7,720	10,200	8,760	7,330
as CO ₃ ^b	31,600	38,000	43,200	46,600	53,000	55,500	44,900	38,600	51,000	43,800	36,600
OH ⁻	12,200	15,000	15,800	17,700	18,800	21,900	24,700	29,400	23,700	17,000	15,200
Formate	1,210	1,520	1,660	1,690	1,910	1,870	2,080	2,460	1,750	1,550	1,590
Acetate	537	747	894	912	1,160	1,020	1,260	1,450	815	922	676
Glycolate	<141	743	831	821	725	790	848	997	<141	665	<141
Oxalate	433	703	692	688	972	<346	<346	<346	<346	<346	<346
Nitrite	38,300	52,600	61,600	63,300	69,800	74,000	85,400	103,000	68,200	52,800	50,100
Nitrate	137,000	188,000	220,000	226,000	247,000	260,000	269,000	278,000	241,000	187,000	178,000
Fluoride	1,420	1,660	1,900	1,880	1,970	665	600	534	795	1,050	1,610
Phosphate	2280	<250	<250	<250	<250	<250	<250	<250	<250	<250	1,740
Sulfate	6,670	7,790	8,970	9,190	9,950	3,670	3,000	2,520	3,410	5,000	7,130
Chloride	1,690	2,430	2,960	3,020	3,320	3,430	3,910	4,730	3,170	2,410	2,420
Bromide	<870	<870	<870	<870	<870	<870	<870	<870	<870	<870	<870

Table 4-1. Results of Analyses of Tank 241-AW-106 Boildown Sample Liquids. (2 sheets)

(All analysis results in units of µg/mL)

Test Sample	CP	CON-1	CON-2	CON-3	CON-4	CON-5	CON-6	CON-7	DIL-1	DIL-2	DIL-3
% WVR ^{18°C}	0.00	15.49	23.28	28.99	34.67	39.35	44.09	48.71	34.42	24.07	9.98
Na	127,000	149,000	165,000	177,000	188,000	199,000	210,000	205,000	186,000	166,000	145,000
Al	5,870	7,030	7,850	8,480	9,050	9,820	11,700	12,600	9,180	8,030	6,890
Si	51	167	96	77	84	83	105	111	83	70	61
P	690	403	391	332	302	297	315	328	344	372	461
(as PO ₄) ^c	2,120	1,240	1,200	1,020	926	911	966	1,010	1,060	1,140	1,410
S	2,160	2,520	2,810	3,010	3,080	1,190	1,080	981	1,360	1,950	2,520
(as SO ₄) ^c	6,470	7,550	8,420	9,020	9,230	3,570	3,240	2,940	4,080	5,840	7,550
K	4,420	5,200	5,760	6,210	6,630	7,180	8,310	9,230	6,720	5,890	5,070
Ca	<160	<160	<160	<160	<160	<160	<160	<160	<160	<160	<160
Cr	484	594	656	707	753	816	904	1,050	771	676	581
Fe	48	49	58	63	65	73	79	96	68	60	53
Mo	23	29	31	33	35	39	45	49	37	32	27
Cd	3	3	3	4	4	4	5	6	4	3	3
Ni	21	24	27	28	30	32	35	41	31	28	24
ChgBal (+/-)	1.04	0.94	0.91	0.93	0.90	0.92	0.94	0.86	0.90	1.01	0.95

^a ΔTOC µg/mL = µg/mL TOC – [(µg/mL Formate × 0.2668) + (µg/mL Acetate × 0.4068) + (µg/mL Glycolate × 0.3201) + (µg/mL Oxalate × 0.2729)].^b µg/mL CO₃ = µg/mL TIC × 4.9961.^c P and S were analyzed by ICP-AES. Analysis results were converted to phosphate and sulfate as follows: PO₄ µg/mL = µg/mL P × 3.0662 and SO₄ µg/mL = µg/mL S × 2.9959.

5 DATA ANALYSIS

5.1 DENSITY

In this report, bulk density, D_{Bulk} , is the density of a total sample, i.e., the density of the combined liquid and solid fractions of a sample. Liquid densities, D_{Liq} are the measured densities of the C-Liq portion of the samples processed in 15-mL centrifuge cones. The density of the initial composite is reported as a D_{Bulk} when measured in triplicate in 100-mL volumetric flasks and as a D_{Liq} when measured on the subsample in the 15-mL cone.

5.1.1 Bulk Density of Tank 241-AW-106 Boildown Samples

The $D_{\text{Bulk}}^{27.1\text{ }^{\circ}\text{C}}$ for the initial composite is believed to be the most accurately measured density in this study since it was obtained using 100-mL volumetric flasks. The $D_{\text{Bulk}}^{18\text{ }^{\circ}\text{C}}$ values, tabulated in Table 3-3, are based on volume measurements of the boildown samples, at 18.0 °C, in the 15-mL centrifuge cones in which they were collected. These volume (and $D_{\text{Bulk}}^{18\text{ }^{\circ}\text{C}}$) measurements were made as carefully as possible but are less accurate than those for the initial composite.

In Table B-2 (Attachment B), the additive volumes model calculations are reset to a base temperature of 18.0 °C. This temperature was chosen to represent common temperatures of the waste tanks. The volume of the initial composite sample was corrected to account for cooling. Previous measurements (Mem-052174, “Densities of Caustic Waste Solutions as a Function of Temperature”) showed that the thermal expansion coefficients of two synthetic tank waste concentrates were 4.409×10^{-4} and 4.838×10^{-4} ($\Delta\text{mL/mL}/\Delta^{\circ}\text{C}$) over a range of 22-56.5 °C. Another set of measurements (WRPS-0900372, “Results of Lifetime Testing of Anton Paar DMA 35N Portable Density Meter”) showed that thermal expansion coefficients of a double-shell tank waste simulant were 3.757×10^{-4} ($\Delta\text{mL/mL}/\Delta^{\circ}\text{C}$) from 18-30 °C and 6.843×10^{-4} ($\Delta\text{mL/mL}/\Delta^{\circ}\text{C}$) from 30-42 °C. An average value of 4.335×10^{-4} ($\Delta\text{mL/mL}/\Delta^{\circ}\text{C}$) was used to adjust the initial composite volume. The corresponding $D_{\text{Bulk}}^{18\text{ }^{\circ}\text{C}}$ was 1.271 g/mL.

The calculated $D_{\text{Model}}^{18\text{ }^{\circ}\text{C}}$ and measured $D_{\text{Bulk}}^{18\text{ }^{\circ}\text{C}}$ values are plotted against $CR_{\text{Model}}^{18\text{ }^{\circ}\text{C}}$ in Figure 5-1. The $D_{\text{Liq}}^{18\text{ }^{\circ}\text{C}}$ values have also been plotted for comparison. In this figure and all other plots in this report, values for the initial test composite (CP) and the volume reduction sequence samples (CON-1 to CON-7) are displayed with solid data markers; values for the dilution sequence samples (DIL-1 to DIL-3) are displayed with hollow data markers of the same shape and border color.

The plot of measured $D_{\text{Bulk}}^{18\text{ }^{\circ}\text{C}}$ vs. $CR_{\text{Model}}^{18\text{ }^{\circ}\text{C}}$ in Figure 5-1 clearly deviates from the linear projection of the additive volumes model. The concentrate volumes indicated by the $D_{\text{Bulk}}^{18\text{ }^{\circ}\text{C}}$ values are larger than those predicted by the additive volumes model. Small downward curvature in plots of density vs. CR is common for concentrated solutions of chemical species found in tank wastes. It is also quite likely that as the quantity of solid precipitates in the concentrates increases, the additive volumes assumption of the model becomes an increasingly

poor one. The pronounced decrease in the slope of the $D_{\text{Liq}}^{18^\circ\text{C}}$ plot beginning at CR 1.7 (Sample CON-5) suggests that this is a factor.

Figure 5-1. Comparison of Model and Measured Bulk Densities.

5.1.2 Test Values of CR and %WVR

The measured $D_{\text{Bulk}}^{18^\circ\text{C}}$ values can be used to calculate the virtual volumes of 18.0°C pot concentrates at each step of the boildown test. These volumes can then be used to calculate values of CR and %WVR actually reached, $CR^{18^\circ\text{C}}$ and %WVR $^{18^\circ\text{C}}$. These calculations are shown in Table 5-1. The calculation chain proceeds down a column of the table for each boildown step.

1. The weight and volume of concentrate at the beginning of the step are entered. These values are the weight and volume of concentrate at the end of the previous step.
2. The weight of the concentrate is then adjusted by the weight of water removed/added.
3. The new concentrate weight is converted to a new volume by dividing by $D_{\text{Bulk}}^{18^\circ\text{C}}$.
4. The $CR^{18^\circ\text{C}}$ is then calculated using Equations 3-1 and 3-5.
5. The %WVR $^{18^\circ\text{C}}$ is then calculated using Equation 3-6.
6. The final concentrate weight is then calculated by subtracting the weight of sample removed.
7. The final step concentrate weight is converted to a final step volume by dividing by $D_{\text{Bulk}}^{18^\circ\text{C}}$.

Table 5-1. Calculation of Test Values of CR and %WVR.

	CP	CON 1	CON 2	CON 3	CON 4	CON 5	CON 6	CON 7
Wt Concentrate (g)	618.2	618.2	525.2	470.8	427.0	384.1	344.8	306.9
Vol Concentrate (mL)	488.1	488.1	400.0	350.5	311.9	274.4	242.2	210.6
ΔH_2O (g)	0.000	76.519	37.562	26.617	25.357	21.359	19.436	18.014
Wt Concentrate (g)	618.2	541.7	487.7	444.2	401.6	362.7	325.4	288.9
$D_{Bulk}^{18^\circ C}$ (g/mL)	1.267	1.313	1.343	1.369	1.400	1.424	1.458	1.495
Vol Concentrate (mL)	488.1	412.5	363.1	324.5	286.9	254.8	223.2	193.2
$CR^{18^\circ C}$	1.000	1.183	1.304	1.408	1.531	1.649	1.789	1.950
% WVR $^{18^\circ C}$	0.00	15.49	23.28	28.99	34.67	39.35	44.09	48.71
Wt Sample Rmvd (g)	0.000	16.466	16.856	17.207	17.552	17.882	18.466	19.006
Wt Concentrate (g)	618.2	525.2	470.8	427.0	384.1	344.8	306.9	269.9
Vol Concentrate (mL)	488.1	400.0	350.5	311.9	274.4	242.2	210.6	180.5

	DIL 1	DIL 2	DIL 3
Wt Concentrate (g)	269.9	305.1	323.4
Vol Concentrate (mL)	180.5	218.3	240.2
ΔH_2O (g)	-52.618	-35.223	-46.595
Wt Concentrate (g)	322.5	340.4	367.0
$D_{Bulk}^{18^\circ C}$ (g/mL)	1.398	1.346	1.299
Vol Concentrate (mL)	230.8	252.8	284.7
$CR^{18^\circ C}$	1.525	1.317	1.111
% WVR $^{18^\circ C}$	34.42	24.07	9.98
Wt Sample Rmvd (g)	17.386	16.951	16.308
Wt Concentrate (g)	305.1	323.4	353.7
Vol Concentrate (mL)	218.3	240.2	272.2

The values of $CR^{18^\circ C}$ and %WVR $^{18^\circ C}$ calculated in Table 5-1 are the boildown progress parameters used throughout the remainder of this report. The $D_{Bulk}^{18^\circ C}$ values are plotted against $CR_{Model}^{18^\circ C}$ and $CR^{18^\circ C}$ in Figure 5-2 for comparison.

Figure 5-2. Bulk Densities at 18 °C versus Concentration Ratio.

5.1.3 Volumes and Densities at Process Temperatures

Estimates of D_{Bulk} of the concentrated composite at boildown process temperatures (boiling temperatures) are of interest as an indicator of real-time densities that may be observed during a 242-A Evaporator campaign. To estimate these in-process D_{Bulk} values, the volumes of the boildown samples at 18.0 °C were adjusted to estimated volumes at the boiling temperatures of the pot concentrates at 60 Torr.

The temperature adjustment process is shown in Table 5-2. The total and C-Slds volumes at 18.0 °C are the base measurements. The fraction of the measured C-Slds volumes that are true solids must be assumed and is assigned a value of 0.5 in the table. The volumes of the solid and liquid portions of the samples at 18.0 °C are then calculated. A thermal expansion coefficient of $4.335 \times 10^{-4} (\Delta\text{mL/mL})/\Delta^\circ\text{C}$ was used to adjust the volumes of the liquids from 18-30 °C. A coefficient of $5.364 \times 10^{-4} (\Delta\text{mL/mL})/\Delta^\circ\text{C}$ was then used to adjust these volumes from 30 °C to the measured boiling temperatures at 60 Torr. The sources of the above thermal expansion factors were noted in Section 5.1.1.

The adjusted total sample volumes were then calculated by adding the volumes of the 18.0 °C solids and the adjusted liquid volumes. Temperature reported adjusted densities, $D_{\text{Bulk}}^{60 \text{ Torr}}$, were then obtained by dividing the sample weights by the adjusted total volumes.

Table 5-2. Adjusted Sample Volumes and Densities at Process Temperatures.[Adjusted densities of samples at boiling temperatures at 60 Torr (T_3) in bottom-right column.]

				Vol _{Solids} / Vol _{C-Slds}		
				0.500		
Sample	Wt _{Total} (g)	T ₁ (°C)	Vol _{Total} at T ₁ (mL)	Vol _{C-Slds} at T ₁ (mL)	Vol _{Solids} at T ₁ (mL)	Vol _{Liquid} at T ₁ (mL)
CP	16.275	18.0	12.85	0.00	0.000	12.85
CON-1	16.466	18.0	12.54	0.07	0.035	12.51
CON-2	16.856	18.0	12.55	0.10	0.050	12.50
CON-3	17.207	18.0	12.57	0.15	0.075	12.50
CON-4	17.552	18.0	12.54	0.19	0.095	12.45
CON-5	17.882	18.0	12.56	0.40	0.200	12.36
CON-6	18.466	18.0	12.67	3.20	1.600	11.07
CON-7	19.006	18.0	12.71	4.00	2.000	10.71
DIL-1	17.386	18.0	12.44	0.55	0.275	12.17
DIL-2	16.951	18.0	12.59	0.32	0.160	12.43
DIL-3	16.308	18.0	12.55	0.10	0.050	12.50

Sample	$(\Delta \text{mL/mL}) / \Delta ^\circ \text{C}$					
	0.00043349			0.00053635		
	T ₂ (°C)	Vol _{Liquid} at T ₂ (mL)	T ₃ (°C)	Vol _{Liquid} at T ₃ (mL)	Vol _{Total} at T ₃ (mL)	D _{Bulk} at T ₃ (g/mL)
CP	30.0	12.92	46.04	13.03	13.03	1.249
CON-1	30.0	12.57	47.32	12.69	12.72	1.294
CON-2	30.0	12.57	47.82	12.69	12.74	1.324
CON-3	30.0	12.56	48.95	12.69	12.76	1.348
CON-4	30.0	12.51	49.59	12.64	12.74	1.378
CON-5	30.0	12.42	50.78	12.56	12.76	1.401
CON-6	30.0	11.13	51.66	11.26	12.86	1.436
CON-7	30.0	10.77	51.66	10.89	12.89	1.474
DIL-1	30.0	12.23	49.50	12.36	12.63	1.376
DIL-2	30.0	12.49	48.11	12.62	12.78	1.327
DIL-3	30.0	12.57	46.83	12.68	12.73	1.281

In the above calculations, the 18.0 °C C-Slds are assumed to contain a constant 50% interstitial liquid, and the volumes of solids present at 18.0 °C and at process temperatures are assumed to be equal. Both these assumptions are only approximations. The impact of the assumed solids content of the samples at elevated temperature on the adjusted volumes increases as the solids volume increases and is not large until large volumes of solids are present.

The measured $D_{\text{Bulk}}^{18^\circ\text{C}}$ and estimated $D_{\text{Bulk}}^{60\text{ Torr}}$ values are plotted against $\%WVR^{18^\circ\text{C}}$ in Figure 5-3. The estimated $D_{\text{Bulk}}^{60\text{ Torr}}$ values are based on assumptions (true solids content at process temperatures) and indirect supporting data (liquid thermal expansion coefficients). The temperature-adjusted values do indicate, however, that real-time measurements of the densities of boildown composite will return values that are smaller than those based on measurements at lower temperatures. For example, for Sample CON-5, collected during the initial onset of solids, the estimated $D_{\text{Bulk}}^{60\text{ Torr}}$ is 0.022 g/mL smaller than the measured $D_{\text{Bulk}}^{18^\circ\text{C}}$ value.

Figure 5-3. Bulk Densities at Process Temperatures versus $\%WVR^{18^\circ\text{C}}$.

$$\begin{aligned} \text{Fit Lines: } D_{\text{Bulk}}^{18^\circ\text{C}} &= (7.85 \times 10^{-7})(\%WVR)^3 - (1.84 \times 10^{-6})(\%WVR)^2 + (2.91 \times 10^{-3})(\%WVR) + 1.27 \\ D_{\text{Bulk}}^{60\text{ Torr}} &= (9.76 \times 10^{-7})(\%WVR)^3 - (1.42 \times 10^{-5})(\%WVR)^2 + (2.99 \times 10^{-3})(\%WVR) + 1.25 \end{aligned}$$

5.2 BOILDOWN TEMPERATURE CURVES

The boiling temperatures (T_{Corr}) of the AW-106 composite at the three nominal test pressures of 40, 60, and 80 Torr are plotted against boildown progress in Figure 5-4. The boiling temperatures are taken from Table B-2 in Attachment B. Boiling temperatures are plotted against $\%WVR^{18^\circ\text{C}}$ in Figure 5-4(a) and against estimated $D_{\text{Bulk}}^{60\text{ Torr}}$ in Figure 5-4(b).

The temperature curves shown in the figures were constrained to pass through the reference boiling temperatures and densities of pure water at the nominal test pressures. The resulting curves display steadily increasing boiling temperatures as the volume reduction progressed without any significant discontinuities. Within the estimated measurement precision, boiling

temperatures measured during the dilution sequence at 60 Torr were those that would have been predicted based on the concentration sequence measurements.

Figure 5-4. Boiling Temperature versus Boildown Progress.

5.3 QUANTITY OF SOLIDS IN COOL CONCENTRATES

5.3.1 Boildown Volume Reduction Samples

The quantities of solids found in the original composite and the 7 samples that were withdrawn from the boildown pot during the volume reduction sequence (CP through CON-7) and then cooled to 18.0 °C for 5 days are graphically displayed in Figure 5-5. The quantity of solids data was tabulated in Table 3-3. Three quantities are displayed against $D_{\text{Bulk}}^{60 \text{ Torr}}$ in Figure 5-5(a): the vol% S-Slds found after a maximum of 42 hrs¹ at hot cell ambient temperature (~24.4 °C), the vol% S-Slds found after the samples had been in the 18.0 °C water bath for 5 days, and the vol% C-Slds found after the samples had been in the water bath and then centrifuged. Photographs of the S-Slds and C-Slds in the samples are presented in Attachment C.

Settled solids begin to be observed in Sample CON-5 and quickly increased in volume percent for CON-6 and CON-7. A small amount of solids were also present in the centrifuge cones for CON-1 through CON-4 but were attached to the cone wall. These solids appeared after sample collection and were measured only after centrifugation when they were forced to the bottom of the cone.

Figure 5-5(a) and the photographs in Attachment C indicate that most of the solids in the boildown samples were present after cooling to ambient hot cell temperatures as the volumes of additional solids that formed while the samples were in the 18.0 °C water bath were smaller or roughly equal to the decreases in the volumes of the S-Slds due to compaction. Sample photographs and observations during the boildown also suggest that a significant portion of the solids found in the 18.0 °C concentrate samples were already present in the boildown pot at process temperatures. Even though some solids precipitated and adhered to the cone surface during cooling, these amounts were small as seen by the red bars for Samples CON-1 through CON-4.

Comparison of the vol% S-Slds and vol% C-Slds in the samples after cooling to 18.0 °C for 5 days is informative. The samples settled to produce a clear supernatant liquid within a few hours after removal from the boildown pot. The vol% C-Slds data suggests that the initial volume of S-Slds found in concentrated evaporator feeds might be expected to decrease by as much as 50% as the S-Slds compact over time.

In Figure 5-5(b) the vol% C-Slds and wt% C-Slds data are compared. Both of these quantities can be difficult to measure accurately when small quantities of solids are present. Nevertheless, the two data sets display very similar trends in the increase of solids with boildown progress.

¹ Sample CON 1 sat at hot cell ambient temperature for 42 hrs. The remaining 6 samples sat at hot cell ambient temperature for 18-24 hrs.

Figure 5-5. Quantity of Solids in Cooled Concentrates.

Part of the apparent increase in the amounts of solids present in the concentrates as the volume reduction progresses is due solely to the reduction in the volume of the test slurry. The predicted quantity of solids that would be found in a sample if solids formation ceased after the preceding boildown step is:

$$\text{Predicted \%Slds} = (\% \text{Slds at the end of the previous step}) (CR_{\text{Step}}) \quad (5-1)$$

The predicted, based on Equation 5-1, and measured quantities of solids present in the boildown volume reduction samples are displayed in Figure 5-6 for the vol% and wt% C-Slds data (18.0 °C). This format emphasizes that the quantities of new solids in the CON-1through CON-4 concentrates were relatively small and relatively consistent. The solids begin to precipitate at CON-5 and quickly escalate by CON-6 and increase slightly at CON-7.

Figure 5-6. Quantities of New Solids in Concentrates.

5.3.2 End-point Slurry Dilution Samples

The quantities of solids found in the three dilution sequence samples, DIL-1 through DIL-3, are displayed in Figure 5-7 along with the samples from the concentration steps for reference. Data for the vol% C-Slds and wt% C-Slds found in the samples after cooling in the 18.0 °C water bath are shown.

All the dilution samples contain relatively greater amounts of solids than the surrounding samples from the volume reduction. This suggests that some supersaturation of the composite could have been present before solids were initially observed in CON-5. Another cause of the increased solids amount in the dilution samples could be a low dissolution rate of the solids.

Figure 5-7. Quantity of Solids in Dilution Samples at 18 °C.

5.3.3 Calculated Weights of Solids in Boildown Samples

A check of the volume and density measurements/calculations performed in this study can be made by calculating the weights of dry solids predicted to be present after the concentrates from each volume reduction step cooled to 18.0 °C. After conversion to wt% dry solids values, these calculated weights can be compared to the measured wt% wet C-Slds values.

The calculation series is shown in Table 5-3. Proceeding down a column for each boildown step, the following calculations are performed (rows where the calculations are performed are highlighted in green).

1. The final volume of the concentrate at 18.0 °C ($Vol_{Step}^{18\text{ }^{\circ}\text{C}}$) is calculated:

$$Vol_{Initial}^{18\text{ }^{\circ}\text{C}} / CR^{18\text{ }^{\circ}\text{C}} \quad (5-2)$$

2. The final weight of the step concentrate, Wt_{Step} , is calculated:

$$(Vol_{Step}^{18\text{ }^{\circ}\text{C}}) (D_{Bulk}^{18\text{ }^{\circ}\text{C}}) \quad (5-3)$$

3. The estimated volume of liquid in the concentrate at 18.0 °C, $Vol_{Liq}^{18\text{ }^{\circ}\text{C}}$, is calculated:

$$(Vol_{Step}^{18\text{ }^{\circ}\text{C}}) (f_{Liq}) \quad (5-4)$$

4. The weight of the liquid in the concentrate, Wt_{Liquid} , is calculated:

$$(Vol_{Liq}^{18\text{ }^{\circ}\text{C}}) (D_{Liq}^{18\text{ }^{\circ}\text{C}}) \quad (5-5)$$

5. The weight of dry solids in the concentrate, $Wt_{Dry\ Solids}$, is calculated:

$$Wt_{Step} - Wt_{Liquid} \quad (5-6)$$

6. The wt% of dry solids in the concentrate is calculated:

$$(Wt_{Dry\ Solids} / Wt_{Step}) (100) \quad (5-7)$$

Table 5-3. Estimated Dry Weights of Solids in Concentrates at 18 °C.

Step	CP	CON 1	CON 2	CON 3	CON 4	CON 5	CON 6	CON 7
%WVR ^{18 °C}	0.00	15.49	23.28	29.00	34.67	39.35	44.10	48.71
$Vol_{Initial}^{18\text{ }^{\circ}\text{C}}$ mL	488.1	—	—	—	—	—	—	—
$CR^{18\text{ }^{\circ}\text{C}}$	1.000	1.183	1.304	1.408	1.531	1.649	1.789	1.950
$Vol_{Step}^{18\text{ }^{\circ}\text{C}}$ mL	488.1	412.5	374.5	346.6	318.9	296.1	272.9	250.4
$D_{Bulk}^{18\text{ }^{\circ}\text{C}}$ g/mL	1.267	1.313	1.343	1.369	1.400	1.424	1.458	1.495
Wt_{Step} g	618.4	541.6	502.9	474.5	446.4	421.6	397.9	374.3
f_{Liq}	1.000	0.997	0.996	0.994	0.992	0.984	0.874	0.843
$Vol_{Liq}^{18\text{ }^{\circ}\text{C}}$ mL	488.1	411.3	373.0	344.5	316.3	291.3	238.5	211.1
$D_{Liq}^{18\text{ }^{\circ}\text{C}}$ g/mL	1.267	1.318	1.348	1.371	1.400	1.421	1.427	1.431
Wt_{Liquid} g	618.4	542.0	502.7	472.4	442.8	414.0	340.3	302.0
$Wt_{Dry\ Solids}$ g	0.0	-0.4	0.2	2.1	3.6	7.6	57.6	72.3
$Wt\%_{Dry\ Solids}$	0.0	-0.1	0.0	0.4	0.8	1.8	14.5	19.3
$Wt\%_{Wet\ 18\text{ }^{\circ}\text{C}\ C-Slds}$	0.0	0.9	1.1	1.5	2.0	6.5	27.5	33.5

The liquid fraction, f_{Liq} , was estimated by assuming that the C-Slds from each concentrate contained 50 vol% solids and 50 vol% interstitial liquid. This was the same assumption used to calculate the total volume of liquid in the boildown samples at 18.0 °C (Section 5.1.3).

The calculated wt% dry solids in the pot concentrates and the wt% wet 18 °C C-Slds measured in the boildown samples (from Table 3-3) are compared graphically in Figure 5-8. The two values display a very similar trend in solids weight versus boildown progress. The relative agreement of the calculated and measured solids weights suggests that the volumes and densities measured/calculated in this study are internally consistent and reasonably accurate.

Figure 5-8. Calculated and Measured Weights of Solids in Concentrates.

5.4 COMPOSITION OF BOILDOWN SOLIDS

5.4.1 Quantities of Species Remaining in Solution

Concentrations of chemical species in the C-Liq fractions of the AW-106 test composite and the 10 boildown test samples are tabulated in Table 4-1. In order to better discern how the amounts of the chemical species changed during the progress of the boildown, this data was reformatted to show the estimated total quantities of species in solution after the concentrates were cooled to 18.0 °C.

The total weight of a species present in a pot concentrate is:

$$Wt_{Species} = Wt_{In\ solution} + Wt_{In\ precipitated\ solids} \quad (5-8)$$

From Eq. 3-1, $CR_{Total} = Vol_{Composite}/Vol_{Pot\ Concentrate}$, the total weight of a species present in a pot concentrate is, therefore:

$$Wt_{Species} = [(g/L)_{C-Liq} \times (0.4881\ L/CR^{18^\circ C}) \times f_{Liq}] + [(g/L)_{C-Slds} \times (0.4881\ L/CR^{18^\circ C}) \times f_{Slds}] \quad (5-9)$$

where f_{Liq} and f_{Slds} are the volume fractions of liquid and solids in the concentrate.

If a species is not removed from the liquid phase by precipitation (or volatilization) during a boildown, the total weight of the species in a pot concentrate reduces to

$$Wt_{Species} = Wt_{In\ Solution} = (g/L)_{C-Liq} \times (0.4881\ L/CR^{18^\circ C}) \times f_{Liq} \quad (5-10)$$

These values are displayed for the boildown samples in Figure 5-9(a)-(u). The ‘Constant Wt’ line in each plot shows the weight of the species that was present in the 488.1 mL AW-106 composite added to the pot at the beginning of the boildown test (in cases where the reported result for the CP sample was arbitrarily low, the result for the DIL-3 sample was used instead). As previously noted, values for the test composite (CP) and the volume reduction sequence samples (CON-1 to CON-7) are displayed with solid data markers; values for the dilution sequence samples (DIL-1 to DIL-3) are displayed with hollow data markers of the same shape. Plots for phosphate, bromide, and Ca are not included because insufficient or no analytical results exceeded reported detection limits. The phosphate plot in Figure 5-9 (k) was generated using the results from the detected phosphorous in solution.

If a species is not removed from the liquid phase by precipitation (or volatilization) during a boildown, the calculated weights for all the samples should plot on or near the Constant Wt line. If a species is removed from solution by precipitation, species weights calculated using Equation 5-10 should fall below the Constant Wt line for some or all of the boildown samples.

Use of a reasonably accurate value of f_{Liq} is of importance (particularly for highly concentrated species and/or when large quantities of solids are present). However, the values for f_{Liq} and f_{Slds} were not directly measured. Values for f_{Liq} were estimated using the same assumed composition of sample C-Slds—50 vol% solids and 50 vol% interstitial liquid—used in previous calculations (Sections 5.1.3 and 5.3.3).

The errors associated with the displayed weights of species in solution combine analytical errors, errors in determination of $\%WVR^{18^\circ\text{C}}$ ($CR^{18^\circ\text{C}}$) values, and errors in estimation of f_{Liq} . The displayed values are, however, of sufficient accuracy to distinguish between changes due to removal/addition of water from/to the boildown pot and changes due to solids formation.

Reported minimum detection limit (MDL) values associated with each species have been converted to minimum detectable weight (MDW) values for each sample in the same manner used to calculate the weights in solution. The MDW values are displayed as small horizontal bars below each data point for the boildown samples.

Complementary to the weights of species in solution are the estimated weights of species in the solids in the 18.0 °C concentrates. These estimates can be calculated by subtracting the weights of a species remaining in solution from the Constant Wt value. The estimated weights of chemical species that would be found in precipitated solids of the pot concentrates from steps CON-5, CON-6, and CON-7 which were cooled to 18.0 °C are displayed in Figure 5-10. (Small negative calculated weights are displayed with red data markers.)

Figure 5-9. Weights of Species Remaining in Solution at 18 °C. (8 sheets)

Figure 5-9. Weights of Species Remaining in Solution at 18 °C. (8 sheets)

Figure 5-9. Weights of Species Remaining in Solution at 18 °C. (8 sheets)

Figure 5-9. Weights of Species Remaining in Solution at 18 °C. (8 sheets)

Figure 5-9. Weights of Species Remaining in Solution at 18 °C. (8 sheets)

Figure 5-9. Weights of Species Remaining in Solution at 18 °C. (8 sheets)

Figure 5-9. Weights of Species Remaining in Solution at 18 °C. (8 sheets)

Figure 5-9. Weights of Species Remaining in Solution at 18 °C. (8 sheets)

Figure 5-10. Estimated Weights of Species in 18 °C Solids.

The chemical analysis data indicate that Cr, Si, Fe, OH, formate, chloride, acetate, and glycolate species do not contribute significantly to the solids formed in the boildown concentrates. Based on the changes in solution concentrations, the major species in the solids are predicted to be Na, nitrate, CO₃, sulfate, phosphate, and fluoride. The plot for fluoride is also very similar to the plot for sulfate suggesting that these two species co-precipitate.

5.4.2 Solid Phase Characterization Results

The 4 samples of C-Slds recovered from the AW-106 boildown samples (as identified in Table 3-2) were submitted to the 222-S Laboratory for SPC to identify solid phases present. Three methods were used: polarized light microscopy (PLM), powder X-ray diffraction (XRD), and scanning electron microscopy with energy-dispersive X-ray spectrometry (SEM/EDX). The SPC analyses were performed by members of the 222-S Special Analytical Services and Process Chemistry groups. Analysis results for the three SPC methods, including photographs and spectra, are presented in Attachment E.

The results of the SPC analyses are summarized in Table 5-4. The quantity descriptors are those used by the analysts in the method-specific reports.

Each of the SPC methods is limited to examination of very small quantities of solids. Homogenization and subsampling of radiologically “hot” samples to collect representative specimens of the required weight/volume is difficult at best. The tabulated results in Table 5-4 are also based on analysis of a single specimen for each method. In addition, specimens for XRD and SEM/EDX analyses are dried during preparation, and solids dissolved in the liquids collected with the samples may precipitate and complicate interpretation of analysis results. For these reasons, the results of the SPC analyses are only considered qualitative and not quantitative.

The solid phase composition of the first three samples, i.e., the C-Slds from the samples preceding and including the end-point slurry, represent the accumulating inventory of solids in the boildown pot during the volume reduction sequence. The final sample [Table 5-4(d)] shows the solid phases that remain after dilution of the end-point slurry solids was complete.

Table 5-4. Solid Phases Identified in C-Slds Samples. (2 sheets)(a) S13T001244: Composite of C-Slds from Samples CON-3, CON-4, and CON-5 (39.3 %WVR^{18 °C})

Solid Phase	Formula	Observations of Characterization Technique		
		XRD	SEM/EDX	PLM
Thermonatrite (sodium carbonate monohydrate)	Na ₂ CO ₃ ·H ₂ O	Major	Moderate	Moderate
Natrophosphate (sodium fluoride phosphate hydrate)	Na ₇ F(PO ₄) ₂ ·19 H ₂ O	Major	Major	Major
Kogarkoite (sodium fluoride sulfate)	Na ₃ FSO ₄	Minor	Major	Major
Sodium nitrate	NaNO ₃	Major ^a	—	—
Sodium nitrite	NaNO ₂	Minor ^a	—	—

^a Identified as a probable specimen preparation artifact where solids dissolved in the liquid collected with the sample precipitated upon drying.(b) S13T001245: C-Slds from Sample CON-6 (44.1 %WVR^{18 °C})

Solid Phase	Formula	Observations of Characterization Technique		
		XRD	SEM/EDX	PLM
Thermonatrite	Na ₂ CO ₃ ·H ₂ O	Minor	Major	Major
Natrophosphate	Na ₇ F(PO ₄) ₂ ·19H ₂ O	Minor	Moderate	Moderate
Kogarkoite	Na ₃ FSO ₄	Minor	Moderate	Moderate
Natroxalate (sodium oxalate)	Na ₂ C ₂ O ₄	—	—	Minor
Sodium nitrate	NaNO ₃	Major ^a	Trace	Trace
Sodium nitrite	NaNO ₂	Minor ^a	—	—

^a Identified as a probable specimen preparation artifact where solids dissolved in the liquid collected with the sample precipitated upon drying.(c) S13T001246: C-Slds from end point slurry Sample CON-7 (48.7 %WVR^{18 °C})

Solid Phase	Formula	Observations of Characterization Technique		
		XRD	SEM/EDX	PLM
Thermonatrite	Na ₂ CO ₃ ·H ₂ O	Major	Major	Major
Natrophosphate	Na ₇ F(PO ₄) ₂ ·19H ₂ O	Minor	Minor	Minor
Kogarkoite	Na ₃ FSO ₄	Minor	Minor	Minor
Natroxalate	Na ₂ C ₂ O ₄	—	—	Minor
Sodium nitrate	NaNO ₃	Major ^a	—	Trace
Sodium nitrite	NaNO ₂	Minor ^a	—	—

^a Identified as a probable specimen preparation artifact where solids dissolved in the liquid collected with the sample precipitated upon drying.

Table 5-4. Solid Phases Identified in C-Slds Samples. (2 sheets)(d) S13T001254: C-Slds from end-point dilution (Sample DIL-3 at 10.0 %WVR^{18 °C})

Solid Phase	Formula	Observations of Characterization Technique		
		XRD	SEM/EDX	PLM
Natroxalate	Na ₂ C ₂ O ₄	Major	Major	Major
Natrophosphate	Na ₇ F(PO ₄) ₂ ·19 H ₂ O	Minor	Minor	Minor
Kogarkoite	Na ₃ FSO ₄	—	—	Minor
Thermonatrite	Na ₂ CO ₃ ·H ₂ O	Major	—	Trace
Sodium nitrate	NaNO ₃	Major ^a	—	—
Sodium nitrite	NaNO ₂ ^a	Minor ^a	—	—

^a Identified as a probable specimen preparation artifact where solids dissolved in the liquid collected with the sample precipitated upon drying.

5.4.3 Solid Phases Present in Concentrate Solids

In Figure 5-11, the chemical analysis data of Section 5.4.1 and the SPC results of Section 5.4.2 are combined. The estimated weights of the chemical species in the solid fractions of the 18.0 °C concentrates (displayed in Figure 5-10) were first converted to weights of solid phases identified in SPC analysis. The weights of the solid phases were then adjusted so the sums of the phase weights for each boildown step were equal to the estimated dry solids weights calculated in Section 5.3.3. The adjusted phase weights were then converted to solid phase volumes by dividing by the reference densities of the solid phases.

In general, the AW-106 boildown testing indicates that kogarkoite (Na₃FSO₄), natrophosphate [Na₇F(PO₄)₂·19 H₂O], and sodium nitrate are the first species to precipitate from the composite as it is reduced, and given sufficient time/nucleation sites, natrophosphate can form earlier than when solids first appeared in the boildown apparatus at 39.3 %WVR.

By CON-6, 44.1 %WVR, much of the phosphate, sulfate, and fluoride is depleted from the solution (~80% for each species), and the next major species to form are sodium nitrate and sodium carbonate (Na₂CO₃·H₂O).

During dilution of the endpoint slurry, sodium nitrate, sodium carbonate, and natrophosphate readily dissolve, and the kogarkoite does go back into solution but at a much lower rate. Eventually, by DIL-3, sodium oxalate remains as the major component of the solids. Sodium oxalate was observed in trace amounts in the concentration samples by only one of the SPC methods due to the relative small amounts present compared to the other species in the solids.

Figure 5-11. Estimated Vol% of Solid Phases in Concentrate Solids.

6 QUALITY ASSURANCE

6.1 HOT CELL OPERATIONS

As discussed in Section 2.2, temperature measurements recorded during the hot cell boildown operations were corrected to true readings provided by a certified, Pt-resistance (RTD) thermometer. The Certificate of Calibration for this reference thermometer was issued September 5, 2012 and is valid for 1 year. A copy of the calibration certificate is included in the project file.

Pressure measurements in the hot cell operations were indirectly calibrated through the verified temperature readings. The measured pressures over pure water boiling at measured temperatures were compared with tabulated vapor pressures of pure water at the same temperatures.

The in-tolerance status of each analytical balance used during the boildown study was verified at a minimum of $\pm 0.1\%$ before use or daily, whichever was less frequent (ATS-LO-140-008, "222-S Laboratory Routine Use and Quality Assurance for Analytical Balances at 222-S Laboratory Complex"). The calibration verification measurements were recorded on Balance Calibration Verification Check Sheets. Copies of the check sheets are included in the project file.

6.2 LABORATORY ANALYSES

Quality control measurements required to ensure the quality of the analyses of the boildown samples performed at the 222-S Laboratory are specified in ATS-MP-1032, *222-S Laboratory Quality Assurance Project Plan*, and in ATL-MP-1011, *ATL Quality Assurance Project Plan for 222-S Laboratory*. The results of all quality control measurements performed are included in the transcript of the analytical results presented in Attachment D.

6.3 DEVIATIONS FROM TEST PLAN

The AW-106 boildown study was executed, in general, as described in the client-approved laboratory test plan (LAB-PLN-13-00001). The test plan incorporated some minor deviations from the guidance for completion of the boildown study provided in the TSAP (RPP-PLAN-53006); these changes were executed with the concurrence of the 242-A Evaporator Technical Point of Contact.

7 REFERENCES

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ATTACHMENT A

VOLUME CALIBRATION OF CENTRIFUGE CONES

VOLUME CALIBRATIONS OF CENTRIFUGE CONES

The volumes read (Vol_{Read}) from gradations on the 15-mL centrifuge cones used to collect the boildown samples were adjusted to corrected values ($\text{Vol}_{\text{Corrected}}$). The volumetric and gravimetric data collected and calculations performed in deriving the correction functions are presented in Table A-1.

Table A-1. Centrifuge Cone Volume Calibrations. (4 sheets)

Cone ID	Cal Date	H ₂ O		ConeVol = Volume Read on Cone (mL)			
				Wt H ₂ O Added = Wt H ₂ O Added to Cone (g)			
		T (°C)	D (g/mL)	Vol H ₂ O Added = Wt H ₂ O (g) / D H ₂ O (g/mL)			
AW-106 BLDN Cone 2	11/12/12	22.3	0.99770	Cone Vol (mL)	10.10	12.06	14.03
				Wt H ₂ O Added (g)	9.97774	11.93578	13.85823
				Vol H ₂ O (mL)	10.0010	11.9633	13.8898
	11/13/12	20.4	0.99812	Cone Vol (mL)	10.09	12.00	13.98
				Wt H ₂ O Added (g)	9.98991	11.90236	13.80422
				Vol H ₂ O (mL)	10.0087	11.9248	13.8302
Cone 2 — Sample DIL-3				Vol _{Corrected} = (0.99 × Vol _{Read}) + 0.06			

Cone ID	Cal Date	H ₂ O		ConeVol = Volume Read on Cone (mL)			
				Wt H ₂ O Added = Wt H ₂ O Added to Cone (g)			
		T (°C)	D (g/mL)	Vol H ₂ O Added = Wt H ₂ O (g) / D H ₂ O (g/mL)			
AW-106 BLDN Cone 3	11/12/12	22.1	0.99775	Cone Vol (mL)	10.00	12.00	13.94
				Wt H ₂ O Added (g)	9.88795	11.87520	13.73602
				Vol H ₂ O (mL)	9.9105	11.9020	13.7670
	11/13/12	20.4	0.99812	Cone Vol (mL)	10.05	12.05	14.00
				Wt H ₂ O Added (g)	9.93861	11.88029	13.77412
				Vol H ₂ O (mL)	9.9573	11.9027	13.8001
Cone 3 — Sample CON-3				Vol _{Corrected} = (0.98 × Vol _{Read}) + 0.16			

Table A-1. Centrifuge Cone Volume Calibrations. (4 sheets)

Cone ID	Cal Date	H ₂ O		ConeVol = Volume Read on Cone (mL)			
				Wt H ₂ O Added = Wt H ₂ O Added to Cone (g)			
		T (°C)	D (g/mL)	Vol H ₂ O Added = Wt H ₂ O (g) / D H ₂ O (g/mL)			
AW-106 BLDN Cone 4	11/16/12	21.0	0.99799	Cone Vol (mL)	10.00	12.05	14.12
				Wt H ₂ O Added (g)	9.95792	11.98409	13.95255
				Vol H ₂ O (mL)	9.9780	12.0082	13.9806
	11/16/12	21.0	0.9979	Cone Vol (mL)	10.09	12.02	14.05
				Wt H ₂ O Added (g)	10.04527	11.93698	13.87498
				Vol H ₂ O (mL)	10.0655	11.9610	13.9029
Cone 4 — Sample CON-4			Vol _{Corrected} = (0.97 × Vol _{Read}) + 0.29				

Cone ID	Cal Date	H ₂ O		ConeVol = Volume Read on Cone (mL)			
				Wt H ₂ O Added = Wt H ₂ O Added to Cone (g)			
		T (°C)	D (g/mL)	Vol H ₂ O Added = Wt H ₂ O (g) / D H ₂ O (g/mL)			
AW-106 BLDN Cone 5	11/12/12	21.9	0.99779	Cone Vol (mL)	10.05	12.05	13.98
				Wt H ₂ O Added (g)	9.95465	11.91992	13.82598
				Vol H ₂ O (mL)	9.9767	11.9463	13.8566
	11/13/12	20.5	0.99810	Cone Vol (mL)	10.02	12.05	13.95
				Wt H ₂ O Added (g)	9.95389	11.92570	13.79276
				Vol H ₂ O (mL)	9.9728	11.9484	13.8190
Cone 5 — Sample CON-5			Vol _{Corrected} = (0.98 × Vol _{Read}) + 0.11				

Cone ID	Cal Date	H ₂ O		ConeVol = Volume Read on Cone (mL)			
				Wt H ₂ O Added = Wt H ₂ O Added to Cone (g)			
		T (°C)	D (g/mL)	Vol H ₂ O Added = Wt H ₂ O (g) / D H ₂ O (g/mL)			
AW-106 BLDN Cone 6	11/16/12	21.0	0.99799	Cone Vol (mL)	10.11	12.09	13.98
				Wt H ₂ O Added (g)	10.05515	12.01415	13.82372
				Vol H ₂ O (mL)	10.0754	12.0383	13.8515
	11/16/12	21.0	0.9979	Cone Vol (mL)	10.05	12.07	13.95
				Wt H ₂ O Added (g)	10.02131	11.99776	13.81385
				Vol H ₂ O (mL)	10.0415	12.0219	13.8416
Cone 6 — Sample CP			Vol _{Corrected} = (0.98 × Vol _{Read}) + 0.23				

Table A-1. Centrifuge Cone Volume Calibrations. (4 sheets)

Cone ID	Cal Date	H ₂ O		ConeVol = Volume Read on Cone (mL)			
				Wt H ₂ O Added = Wt H ₂ O Added to Cone (g)			
		T (°C)	D (g/mL)	Vol H ₂ O Added = Wt H ₂ O (g) / D H ₂ O (g/mL)			
AW-106 BLDN Cone 8	11/12/12	21.5	0.99788	Cone Vol (mL)	10.05	12.10	13.95
				Wt H ₂ O Added (g)	9.93728	11.93329	13.76967
				Vol H ₂ O (mL)	9.9584	11.9586	13.7986
	11/13/12	20.6	0.99808	Cone Vol (mL)	10.09	12.06	14.00
				Wt H ₂ O Added (g)	9.97530	11.91983	13.80424
				Vol H ₂ O (mL)	9.9943	11.9428	13.8308
Cone 8 — Sample CON-1				Vol _{Corrected} = (0.98 × Vol _{Read}) + 0.08			

Cone ID	Cal Date	H ₂ O		ConeVol = Volume Read on Cone (mL)			
				Wt H ₂ O Added = Wt H ₂ O Added to Cone (g)			
		T (°C)	D (g/mL)	Vol H ₂ O Added = Wt H ₂ O (g) / D H ₂ O (g/mL)			
AW-106 BLDN Cone 10	11/12/12	21.3	0.99793	Cone Vol (mL)	10.05	12.02	13.95
				Wt H ₂ O Added (g)	10.00225	11.92800	13.77958
				Vol H ₂ O (mL)	10.0230	11.9528	13.8082
	11/13/12	20.6	0.99808	Cone Vol (mL)	10.09	12.05	13.95
				Wt H ₂ O Added (g)	10.02537	11.94759	13.83192
				Vol H ₂ O (mL)	10.0447	11.9706	13.8586
Cone 10 — Sample DIL-2			Vol _{Corrected} = (0.98 × Vol _{Read}) + 0.17				

Cone ID	Cal Date	H ₂ O		ConeVol = Volume Read on Cone (mL)			
				Wt H ₂ O Added = Wt H ₂ O Added to Cone (g)			
		T (°C)	D (g/mL)	Vol H ₂ O Added = Wt H ₂ O (g) / D H ₂ O (g/mL)			
AW-106 BLDN Cone 11	11/12/12	21.3	0.99793	Cone Vol (mL)	10.05	12.05	14.00
				Wt H ₂ O Added (g)	9.98536	11.96007	13.85431
				Vol H ₂ O (mL)	10.0061	11.9849	13.8831
	11/13/12	20.6	0.99808	Cone Vol (mL)	10.07	12.07	13.95
				Wt H ₂ O Added (g)	10.06973	11.97845	13.82213
				Vol H ₂ O (mL)	10.0891	12.0015	13.8487
Cone 11 — Sample CON-2			Vol _{Corrected} = (0.98 × Vol _{Read}) + 0.23				

Table A-1. Centrifuge Cone Volume Calibrations. (4 sheets)

Cone ID	Cal Date	H ₂ O		ConeVol = Volume Read on Cone (mL)			
				Wt H ₂ O Added = Wt H ₂ O Added to Cone (g)			
		T (°C)	D (g/mL)	Vol H ₂ O Added = Wt H ₂ O (g) / D H ₂ O (g/mL)			
AW-106 BLDN Cone 13	11/12/12	21.2	0.99795	Cone Vol (mL)	10.07	12.03	14.00
				Wt H ₂ O Added (g)	10.00435	11.91339	13.84452
				Vol H ₂ O (mL)	10.0249	11.9379	13.8730
	11/13/12	20.7	0.99806	Cone Vol (mL)	10.05	12.05	13.98
				Wt H ₂ O Added (g)	9.97052	11.95501	13.82254
				Vol H ₂ O (mL)	9.9899	11.9783	13.8494
Cone 13 — Sample CON-7				Vol _{Corrected} = (0.98 × Vol _{Read}) + 0.15			

Cone ID	Cal Date	H ₂ O		ConeVol = Volume Read on Cone (mL)			
				Wt H ₂ O Added = Wt H ₂ O Added to Cone (g)			
		T (°C)	D (g/mL)	Vol H ₂ O Added = Wt H ₂ O (g) / D H ₂ O (g/mL)			
AW-106 BLDN Cone 14	11/12/12	21.1	0.99797	Cone Vol (mL)	10.02	12.10	13.95
				Wt H ₂ O Added (g)	9.96208	11.97237	13.81411
				Vol H ₂ O (mL)	9.9823	11.9967	13.8422
	11/13/12	20.7	0.99806	Cone Vol (mL)	10.09	11.95	13.95
				Wt H ₂ O Added (g)	10.03283	11.85613	13.81576
				Vol H ₂ O (mL)	10.0524	11.8792	13.8427
Cone 14 — Sample CON-6			Vol _{Corrected} = (0.98 × Vol _{Read}) + 0.14				

Cone ID	Cal Date	H ₂ O		ConeVol = Volume Read on Cone (mL)			
				Wt H ₂ O Added = Wt H ₂ O Added to Cone (g)			
		T (°C)	D (g/mL)	Vol H ₂ O Added = Wt H ₂ O (g) / D H ₂ O (g/mL)			
AW-106 BLDN Cone 15	11/16/12	21.0	0.99799	Cone Vol (mL)	10.09	12.02	14.02
				Wt H ₂ O Added (g)	10.09085	12.03928	13.94215
				Vol H ₂ O (mL)	10.1112	12.0635	13.9702
	11/16/12	20.9	0.99801	Cone Vol (mL)	10.04	12.05	14.02
				Wt H ₂ O Added (g)	10.06847	12.04975	13.95205
				Vol H ₂ O (mL)	10.0887	12.0737	13.9798
Cone 15 — Sample DIL-1				Vol _{Corrected} = (0.98 × Vol _{Read}) + 0.25			

ATTACHMENT B

BOILDOWN HOT CELL DATA LOGS

BOILDOWN HOT CELL DATA LOG

The hot cell data log reproduced in Table B-1 was used to track the progress of the boildown operations and to calculate volumes of water ($\Delta \text{H}_2\text{O}$) that needed to be distilled from or added to the test sample to reach target concentrations or densities. Quantities of water removed from or added to the boildown pot were weighed and then converted to volumes by dividing by the density of pure water at 27.1 °C. The volumes of samples removed from the pot were calculated by dividing the weight of the samples by the model density ($D_{\text{Model}}^{27.1 \text{ °C}}$) calculated by the spreadsheet.

A registered and verified Excel spreadsheet (SVF-1543; SDD RPP-38843) was used to generate the hot cell data log. Within the log, the chronology of entries proceeds from left to right across a row, and then down to the following row.

The primary hot cell data log was subsequently modified by changing the base reference temperature for the model calculations from 27.1 °C to 18.0 °C. This revised data log is presented in Table B-2.

The column headings/entries in the data logs are defined as follows:

Sample Rmvd (mL)	Volume of sample withdrawn from pot at beginning of step as read from volume gradations on centrifuge cone
	= Manual data entry
Pot Vol Initial (mL)	Volume of pot contents after removal of a sample following the conclusion of a preceding concentration/dilution step
	= (Pot Vol Final) _{previous} – (Sample Vol Corrected) _{current}
$\Delta \text{H}_2\text{O}$ (mL)	Volume of water removed from or added to pot contents during a concentration/dilution step read from a graduated cylinder
	= Manual data entry with additions entered as negative values
Pot Vol Final (mL)	Final volume of pot contents for a step
	= (Pot Vol Initial) _{current} – ($\Delta \text{H}_2\text{O}$) _{current}
CR Step	(Incremental) concentration ratio for a step
	= (Pot Vol Initial) _{current} ÷ (Pot Vol Final) _{current}
CR Total	(Cumulative) concentration ratio applicable to a boildown since the last baseline reset
	= (CR Total) _{previous} × (CR Step) _{current}

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%WVR	% waste volume reduction applicable to a boildown since the last baseline reset
	$= \{[(CR \text{ Total})_{\text{current}} - 1.0] \div (CR \text{ Total})_{\text{current}}\} \times 100$
D_{Model} (g/mL)	Calculated density of pot contents, based on simple additive additions model, at the end of a boildown step
	$= [(D_{\text{Initial Composite}} - D_{\text{H}_2\text{O}}) \times CR \text{ Total}] + D_{\text{H}_2\text{O}}$
P_{Read} (Torr)	Pressure in the boildown apparatus read from pressure reader/controller
	= Manual data entry
P_{Corr} (Torr)	Corrected pressure in boildown apparatus
	$= (1.01)(P_{\text{Read}}) + 3.50$
T_{Read} (°C)	Temperature of pot contents from readout of K-type thermocouple/reader
	= Manual data entry
T_{Corr} (°C)	Corrected temperature of pot contents
	$= (2.81 \times 10^{-6})(T_{\text{Read}})^3 - (7.16 \times 10^{-4})(T_{\text{Read}})^2 + (1.04)(T_{\text{Read}}) + 1.20$

The abbreviations used in the row entries in the ‘Action’ column are defined as follows:

CON-#	Boildown volume reduction step # and sample #
DIL-#	Boildown dilution step # and sample #
P/T Step # [P_{nominal}]	Measurement of boiling temperature (T) and system pressure (P) during specified boildown/dilution step (#) at nominal test pressure of 40, 60, or 80 Torr

Table B-1. Tank 241-AW-106 Boildown Hot Cell Data Log. (3 sheets)

$$\text{Vol Initial Composite (mL)} = 618.199 \text{ g} / 1.2659 \text{ g/mL}$$

$$\Delta \text{H}_2\text{O (mL)} = \text{Wt H}_2\text{O} / \text{D}_{\text{H}_2\text{O}} \text{ at } 27.1^\circ \text{C}$$

$$\text{Sample Rmvd (mL)} = \text{Wt Sample} / \text{D}_{\text{Model}}^{27.1^\circ \text{C}}$$

2013		Action	Sample Rmvd (mL)	Pot Vol Initial (mL)	$\Delta \text{H}_2\text{O}$ (mL)	Pot Vol Final (mL)	CR Step	CR Total	%WVR	$\rho \text{H}_2\text{O}$ 0.99649	P Read (torr)	P Calc (torr)	T Read ($^\circ\text{C}$)	T Calc ($^\circ\text{C}$)
Date mm/dd	Time hh:mm									ρ Calc (g/mL)				
02/20	09:30	INITIAL	0.00	488.309	0.000	488.309	1.0000	1.0000	0.000	1.2659	-	-	-	-
	10:40	P/T 0 [40]	0.00	488.309	0.000	488.309	1.0000	1.0000	0.000	1.2659	37	40.9	37.5	38.11
	10:55	P/T 0 [60]	0.00	488.309	0.000	488.309	1.0000	1.0000	0.000	1.2659	57	61.1	45.5	46.04
	11:00	P/T 0 [80]	0.00	488.309	0.000	488.309	1.0000	1.0000	0.000	1.2659	76	80.3	51.4	51.86
	11:10	CON 1a	0.00	488.309	37.382	450.927	1.0829	1.0829	7.655	1.2882	-	-	-	-
	12:34	P/T 1a [40]	0.00	450.927	0.000	450.927	1.0000	1.0829	7.655	1.2882	36	39.9	37.9	38.51
	12:43	P/T 1a [60]	0.00	450.927	0.000	450.927	1.0000	1.0829	7.655	1.2882	57	61.1	46.2	46.73
	12:50	P/T 1a [80]	0.00	450.927	0.000	450.927	1.0000	1.0829	7.655	1.2882	76	80.3	51.7	52.16
	13:02	CON 1b	0.00	450.927	39.406	411.521	1.0958	1.1866	15.725	1.3162	-	-	-	-
	13:49	P/T 1b [40]	0.00	411.521	0.000	411.521	1.0000	1.1866	15.725	1.3162	35	38.9	38.3	38.86
	13:58	P/T 1b [60]	0.00	411.521	0.000	411.521	1.0000	1.1866	15.725	1.3162	57	61.1	46.8	47.32
	14:04	P/T 1b [80]	0.00	411.521	0.000	411.521	1.0000	1.1866	15.725	1.3162	77	81.3	52.7	53.14
		CON 1c	0.00	411.521	0.000	411.521	1.0000	1.1866	15.725	1.3162	-	-	-	-
		P/T 1c [40]	0.00	411.521	0.000	411.521	1.0000	1.1866	15.725	1.3162	-	-	-	-
		P/T 1c [60]	0.00	411.521	0.000	411.521	1.0000	1.1866	15.725	1.3162	-	-	-	-
		P/T 1c [80]	0.00	411.521	0.000	411.521	1.0000	1.1866	15.725	1.3162	-	-	-	-
	14:20	Sample Con-1	12.51	399.011	0.000	399.011	1.0000	1.1866	15.725	1.3162	-	-	-	-

Table B-1. Tank 241-AW-106 Boildown Hot Cell Data Log. (3 sheets)

2013		Action	Sample Rmvd (mL)	Pot Vol Initial (mL)	Δ H ₂ O (mL)	Pot Vol Final (mL)	CR Step	CR Total	%WVR	ρ H ₂ O	ρ Calc (g/mL)	P Read (torr)	P Calc (torr)	T Read (°C)	T Calc (°C)
Date mm/dd	Time hh:mm									0.99649					
02/21	07:56	CON 2	0.00	399.011	37.694	361.317	1.1043	1.3104	23.687	1.3495	-	-	-	-	-
	08:27	P/T 2 [80]	0.00	361.317	0.000	361.317	1.0000	1.3104	23.687	1.3495	36	39.9	39.2	39.75	
	08:33	P/T 2 [60]	0.00	361.317	0.000	361.317	1.0000	1.3104	23.687	1.3495	56	60.1	47.3	47.82	
	08:39	P/T 2 [40]	0.00	361.317	0.000	361.317	1.0000	1.3104	23.687	1.3495	76	80.3	53.2	53.58	
	08:55	Sample Con-2	12.49	348.827	0.000	348.827	1.0000	1.3104	23.687	1.3495	-	-	-	-	-
	09:12	CON 3	0.00	348.827	26.710	322.117	1.0829	1.4190	29.530	1.3788	-	-	-	-	-
	10:04	P/T 3 [40]	0.00	322.117	0.000	322.117	1.0000	1.4190	29.530	1.3788	36	39.9	40.0	40.59	
	10:11	P/T 3 [60]	0.00	322.117	0.000	322.117	1.0000	1.4190	29.530	1.3788	57	61.1	48.5	48.95	
	10:15	P/T 3 [80]	0.00	322.117	0.000	322.117	1.0000	1.4190	29.530	1.3788	77	81.3	54.3	54.71	
	10:27	Sample Con-3	12.48	309.637	0.000	309.637	1.0000	1.4190	29.530	1.3788	-	-	-	-	-
	10:45	CON 4	0.00	309.637	25.450	284.187	1.0896	1.5461	35.322	1.4130	-	-	-	-	-
	11:17	P/T 4 [40]	0.00	284.187	0.000	284.187	1.0000	1.5461	35.322	1.4130	37	40.9	41.3	41.88	
	11:21	P/T 4 [60]	0.00	284.187	0.000	284.187	1.0000	1.5461	35.322	1.4130	56	60.1	49.1	49.59	
	11:24	P/T 4 [80]	0.00	284.187	0.000	284.187	1.0000	1.5461	35.322	1.4130	76	80.3	55.1	55.45	
	11:39	Sample Con-4	12.42	271.767	0.000	271.767	1.0000	1.5461	35.322	1.4130	-	-	-	-	-
	11:54	CON 5	0.00	271.767	21.434	250.333	1.0856	1.6785	40.423	1.4487	-	-	-	-	-
	12:38	P/T 5 [40]	0.00	250.333	0.000	250.333	1.0000	1.6785	40.423	1.4487	36	39.9	41.8	42.38	
		P/T 5 [60]	0.00	250.333	0.000	250.333	1.0000	1.6785	40.423	1.4487	57	61.1	50.3	50.78	
		P/T 5 [80]	0.00	250.333	0.000	250.333	1.0000	1.6785	40.423	1.4487	76	80.3	56.0	56.38	
	12:48	Sample Con-5	12.34	237.993	0.000	237.993	1.0000	1.6785	40.423	1.4487	-	-	-	-	-

Table B-1. Tank 241-AW-106 Boildown Hot Cell Data Log. (3 sheets)

2013		Action	Sample Rmvd (mL)	Pot Vol Initial (mL)	Δ H ₂ O (mL)	Pot Vol Final (mL)	CR Step	CR Total	%WVR	ρ H ₂ O	ρ Calc (g/mL)	P Read (torr)	P Calc (torr)	T Read (°C)	T Calc (°C)
Date mm/dd	Time hh:mm									0.99649					
	13:04	CON 6	0.00	237.993	19.504	218.489	1.0893	1.8283	45.306		1.4891	-	-	-	-
	13:18	P/T 6 [40]	0.00	218.489	0.000	218.489	1.0000	1.8283	45.306		1.4891	36	39.9	43.0	43.52
	13:22	P/T 6 [60]	0.00	218.489	0.000	218.489	1.0000	1.8283	45.306		1.4891	56	60.1	51.2	51.66
	13:25	P/T 6 [80]	0.00	218.489	0.000	218.489	1.0000	1.8283	45.306		1.4891	78	82.3	57.5	57.86
	13:37	Sample Con-6	12.40	206.089	0.000	206.089	1.0000	1.8283	45.306		1.4891	-	-	-	-
	13:57	CON 7	0.00	206.089	18.077	188.012	1.0961	2.0041	50.103		1.5364	-	-	-	-
	14:09	P/T 7 [80]	0.00	188.012	0.000	188.012	1.0000	2.0041	50.103		1.5364	76	80.3	57.6	57.95
	14:10	P/T 7 [60]	0.00	188.012	0.000	188.012	1.0000	2.0041	50.103		1.5364	56	60.1	51.2	51.66
	14:13	P/T 7 [40]	0.00	188.012	0.000	188.012	1.0000	2.0041	50.103		1.5364	37	40.9	43.7	44.26
	14:24	Sample Con-7	12.37	175.642	0.000	175.642	1.0000	2.0041	50.103		1.5364	-	-	-	-
	14:50	DIL 1	0.00	175.642	-52.803	228.445	0.7689	1.5409	35.103		1.4116	-	-	-	-
	15:00	P/T 10 [60]	0.00	228.445	0.000	228.445	1.0000	1.5409	35.103		1.4116	57	61.1	49.0	49.50
	15:08	Sample Dil-1	12.31	216.135	0.000	216.135	1.0000	1.5409	35.103		1.4116	-	-	-	-
	15:26	DIL 2	0.00	216.135	-35.347	251.482	0.8594	1.3243	24.489		1.3533	-	-	-	-
	15:38	P/T 11 [60]	0.00	251.482	0.000	251.482	1.0000	1.3243	24.489		1.3533	57	61.1	47.6	48.11
	16:00	Sample Dil-2	12.53	238.952	0.000	238.952	1.0000	1.3243	24.489		1.3533	-	-	-	-
	16:10	DIL 3	0.00	238.952	-46.759	285.711	0.8363	1.1076	9.713		1.2949	-	-	-	-
	16:23	P/T 12 [60]	0.00	285.711	0.000	285.711	1.0000	1.1076	9.713		1.2949	57	61.1	46.3	46.83
	16:33	Sample Dil-3	12.60	273.111	0.000	273.111	1.0000	1.1076	9.713		1.2949	-	-	-	-

Table B-2. Revised Tank 241-AW-106 Boildown Hot Cell Data Log. (3 sheets)

$$\text{Initial Composite Vol}^{18^{\circ}\text{C}} (\text{mL}) = \text{Vol}^{27.1^{\circ}\text{C}} + [(\text{Vol}^{27.1^{\circ}\text{C}}) (0.00043349 \Delta V/\text{mL}) (-9.1^{\circ}\text{C})]$$

$$\text{Initial Composite D}_{\text{Model}}^{18^{\circ}\text{C}} (\text{g/mL}) = 618.199 \text{ g} / \text{Vol}^{18^{\circ}\text{C}}$$

$$\Delta \text{H}_2\text{O} (\text{mL}) = \text{Wt H}_2\text{O} / \text{D}_{\text{H}_2\text{O}}^{18^{\circ}\text{C}}$$

$$\text{Sample Rmvd} (\text{mL}) = \text{Vol}_{\text{Corrected}} \text{ based on } \text{Vol}_{\text{Read}} \text{ measured from sample photograph}$$

2013		Action	Sample Rmvd (mL)	Pot Vol Initial (mL)	$\Delta \text{H}_2\text{O}$ (mL)	Pot Vol Final (mL)	CR Step	CR Total	$\rho \text{H}_2\text{O}$	0.9986	P Read (torr)	P Calc (torr)	T Read ($^{\circ}\text{C}$)	T Calc ($^{\circ}\text{C}$)
Date mm/dd	Time hh:mm									ρ Calc (g/mL)				
02/20	09:30	INITIAL	0.00	486.383	0.000	486.383	1.0000	1.0000	0.000	1.2710	-	-	-	-
	10:40	P/T 0 [40]	0.00	486.383	0.000	486.383	1.0000	1.0000	0.000	1.2710	37	40.9	37.5	38.11
	10:55	P/T 0 [60]	0.00	486.383	0.000	486.383	1.0000	1.0000	0.000	1.2710	57	61.1	45.5	46.04
	11:00	P/T 0 [80]	0.00	486.383	0.000	486.383	1.0000	1.0000	0.000	1.2710	76	80.3	51.4	51.86
	11:10	CON 1a	0.00	486.383	37.303	449.080	1.0831	1.0831	7.669	1.2936	-	-	-	-
	12:34	P/T 1a [40]	0.00	449.080	0.000	449.080	1.0000	1.0831	7.669	1.2936	36	39.9	37.9	38.51
	12:43	P/T 1a [60]	0.00	449.080	0.000	449.080	1.0000	1.0831	7.669	1.2936	57	61.1	46.2	46.73
	12:50	P/T 1a [80]	0.00	449.080	0.000	449.080	1.0000	1.0831	7.669	1.2936	76	80.3	51.7	52.16
	13:02	CON 1b	0.00	449.080	39.323	409.757	1.0960	1.1870	15.754	1.3219	-	-	-	-
	13:49	P/T 1b [40]	0.00	409.757	0.000	409.757	1.0000	1.1870	15.754	1.3219	35	38.9	38.3	38.86
	13:58	P/T 1b [60]	0.00	409.757	0.000	409.757	1.0000	1.1870	15.754	1.3219	57	61.1	46.8	47.32
	14:04	P/T 1b [80]	0.00	409.757	0.000	409.757	1.0000	1.1870	15.754	1.3219	77	81.3	52.7	53.14
		CON 1c	0.00	409.757	0.000	409.757	1.0000	1.1870	15.754	1.3219	-	-	-	-
		P/T 1c [40]	0.00	409.757	0.000	409.757	1.0000	1.1870	15.754	1.3219	-	-	-	-
		P/T 1c [60]	0.00	409.757	0.000	409.757	1.0000	1.1870	15.754	1.3219	-	-	-	-
		P/T 1c [80]	0.00	409.757	0.000	409.757	1.0000	1.1870	15.754	1.3219	-	-	-	-
	14:20	Sample Con-1	12.54	397.217	0.000	397.217	1.0000	1.1870	15.754	1.3219	-	-	-	-

Table B-2. Revised Tank 241-AW-106 Boildown Hot Cell Data Log. (3 sheets)

2013		Action	Sample Rmvd (mL)	Pot Vol Initial (mL)	Δ H ₂ O (mL)	Pot Vol Final (mL)	CR Step	CR Total	ρ H ₂ O %WVR	0.9986	P Read (torr)	P Calc (torr)	T Read (°C)	T Calc (°C)
Date mm/dd	Time hh:mm									ρ Calc (g/mL)				
02/21	07:56	CON 2	0.00	397.217	37.615	359.602	1.1046	1.3112	23.732	1.3558	-	-	-	-
	08:27	P/T 2 [80]	0.00	359.602	0.000	359.602	1.0000	1.3112	23.732	1.3558	36	39.9	39.2	39.75
	08:33	P/T 2 [60]	0.00	359.602	0.000	359.602	1.0000	1.3112	23.732	1.3558	56	60.1	47.3	47.82
	08:39	P/T 2 [40]	0.00	359.602	0.000	359.602	1.0000	1.3112	23.732	1.3558	76	80.3	53.2	53.58
	08:55	Sample Con-2	12.55	347.052	0.000	347.052	1.0000	1.3112	23.732	1.3558	-	-	-	-
	09:12	CON 3	0.00	347.052	26.654	320.398	1.0832	1.4202	29.589	1.3855	-	-	-	-
	10:04	P/T 3 [40]	0.00	320.398	0.000	320.398	1.0000	1.4202	29.589	1.3855	36	39.9	40.0	40.59
	10:11	P/T 3 [60]	0.00	320.398	0.000	320.398	1.0000	1.4202	29.589	1.3855	57	61.1	48.5	48.95
	10:15	P/T 3 [80]	0.00	320.398	0.000	320.398	1.0000	1.4202	29.589	1.3855	77	81.3	54.3	54.71
	10:27	Sample Con-3	12.57	307.828	0.000	307.828	1.0000	1.4202	29.589	1.3855	-	-	-	-
	10:45	CON 4	0.00	307.828	25.393	282.435	1.0899	1.5479	35.398	1.4203	-	-	-	-
	11:17	P/T 4 [40]	0.00	282.435	0.000	282.435	1.0000	1.5479	35.398	1.4203	37	40.9	41.3	41.88
	11:21	P/T 4 [60]	0.00	282.435	0.000	282.435	1.0000	1.5479	35.398	1.4203	56	60.1	49.1	49.59
	11:24	P/T 4 [80]	0.00	282.435	0.000	282.435	1.0000	1.5479	35.398	1.4203	76	80.3	55.1	55.45
	11:39	Sample Con-4	12.54	269.895	0.000	269.895	1.0000	1.5479	35.398	1.4203	-	-	-	-
	11:54	CON 5	0.00	269.895	21.389	248.506	1.0861	1.6812	40.517	1.4566	-	-	-	-
	12:38	P/T 5 [40]	0.00	248.506	0.000	248.506	1.0000	1.6812	40.517	1.4566	36	39.9	41.8	42.38
		P/T 5 [60]	0.00	248.506	0.000	248.506	1.0000	1.6812	40.517	1.4566	57	61.1	50.3	50.78
		P/T 5 [80]	0.00	248.506	0.000	248.506	1.0000	1.6812	40.517	1.4566	76	80.3	56.0	56.38
	12:48	Sample Con-5	12.56	235.946	0.000	235.946	1.0000	1.6812	40.517	1.4566	-	-	-	-

B-7

LAB-RPT-13-00003 R0
Attachment B

Table B-2. Revised Tank 241-AW-106 Boildown Hot Cell Data Log. (3 sheets)

2013		Action	Sample Rmvd (mL)	Pot Vol Initial (mL)	Δ H ₂ O (mL)	Pot Vol Final (mL)	CR Step	CR Total	ρ H ₂ O %WVR	0.9986	P Read (torr)	P Calc (torr)	T Read (°C)	T Calc (°C)
Date mm/dd	Time hh:mm									ρ Calc (g/mL)				
	13:04	CON 6	0.00	235.946	19.463	216.483	1.0899	1.8323	45.424	1.4977	-	-	-	-
	13:18	P/T 6 [40]	0.00	216.483	0.000	216.483	1.0000	1.8323	45.424	1.4977	36	39.9	43.0	43.52
	13:22	P/T 6 [60]	0.00	216.483	0.000	216.483	1.0000	1.8323	45.424	1.4977	56	60.1	51.2	51.66
	13:25	P/T 6 [80]	0.00	216.483	0.000	216.483	1.0000	1.8323	45.424	1.4977	78	82.3	57.5	57.86
	13:37	Sample Con-6	12.67	203.813	0.000	203.813	1.0000	1.8323	45.424	1.4977	-	-	-	-
	13:57	CON 7	0.00	203.813	18.039	185.774	1.0971	2.0102	50.254	1.5462	-	-	-	-
	14:09	P/T 7 [80]	0.00	185.774	0.000	185.774	1.0000	2.0102	50.254	1.5462	76	80.3	57.6	57.95
	14:10	P/T 7 [60]	0.00	185.774	0.000	185.774	1.0000	2.0102	50.254	1.5462	56	60.1	51.2	51.66
	14:13	P/T 7 [40]	0.00	185.774	0.000	185.774	1.0000	2.0102	50.254	1.5462	37	40.9	43.7	44.26
	14:24	Sample Con-7	12.71	173.064	0.000	173.064	1.0000	2.0102	50.254	1.5462	-	-	-	-
	14:50	DIL 1	0.00	173.064	-52.692	225.756	0.7666	1.5410	35.109	1.4184	-	-	-	-
	15:00	P/T 10 [60]	0.00	225.756	0.000	225.756	1.0000	1.5410	35.109	1.4184	57	61.1	49.0	49.50
	15:08	Sample Dil-1	12.44	213.316	0.000	213.316	1.0000	1.5410	35.109	1.4184	-	-	-	-
	15:26	DIL 2	0.00	213.316	-35.273	248.589	0.8581	1.3224	24.379	1.3588	-	-	-	-
	15:38	P/T 11 [60]	0.00	248.589	0.000	248.589	1.0000	1.3224	24.379	1.3588	57	61.1	47.6	48.11
	16:00	Sample Dil-2	12.59	235.999	0.000	235.999	1.0000	1.3224	24.379	1.3588	-	-	-	-
	16:10	DIL 3	0.00	235.999	-46.661	282.660	0.8349	1.1041	9.427	1.2994	-	-	-	-
	16:23	P/T 12 [60]	0.00	282.660	0.000	282.660	1.0000	1.1041	9.427	1.2994	57	61.1	46.3	46.83
	16:33	Sample Dil-3	12.55	270.110	0.000	270.110	1.0000	1.1041	9.427	1.2994	-	-	-	-

ATTACHMENT C

PHOTOGRAPHS OF BOILDOWN SAMPLES

Figure C-1. Tank 241-AW-106 Samples < 1 Hour Out of Pot.

Figure C-2. Tank 241-AW-106 Samples after 1 day at 24.4 °C in Hot Cell.

C-2

Figure C-3. Tank 241-AW-106 Samples after 5 Days at 18.0 °C.

Figure C-4. Tank 241-AW-106 Samples after 5 Days at 18.0 °C and Centrifuged.

ATTACHMENT D

LABORATORY ANALYSIS RESULTS

LABORATORY ANALYSIS RESULTS

The data summary report for the physicochemical analyses of the AW-106 boildown sample liquids are presented in this attachment. All analyses were performed in the 222-S Laboratory by Advanced Technologies and Laboratories International, Inc. personnel. The following analyses were performed:

Component (Method)	222-S Procedure Specific Analytes
Density (gravimetric)	LA-510-112, "Determination of Density for Free Liquid Samples," Rev/Mod I-0, Advanced Technologies and Laboratories International, Inc., Richland, Washington.
Total inorganic carbon / total organic carbon (acid-sparging/persulfate-oxidation coulometry)	LA-342-100, "Determination of Carbon by Hot Persulfate Oxidation and Coulometric Detection," Rev/Mod J-0, Advanced Technologies and Laboratories International, Inc., Richland, Washington.
Anions (ion chromatography)	LA-533-166, "Ion Chromatographic Analysis of Anions and Small Organic Acids on DIONEX Model ICS 3000" Rev/Mod B-1-A, Advanced Technologies and Laboratories International, Inc., Richland, Washington. Br ⁻ , Cl ⁻ , F ⁻ , NO ₂ ⁻ , NO ₃ ⁻ , PO ₄ ³⁻ , and SO ₄ ²⁻ , and Small organic anions: formate, acetate, oxalate, and glycolate.
Elemental components (inductively coupled plasma-atomic emission)	LA-505-174, "Inductively Coupled Plasma (ICP) Emission Spectrometric Method for the Thermo Scientific iCAP 6500" Rev/Mod A-0, Advanced Technologies and Laboratories International, Inc., Richland, Washington. Priority analytes: Na, Al, Si, P, S, K, Ca, and Cr. All others reported as opportunistic analytes.
Hydroxide (potentiometric titration)	LA-211-102, "Determination of Free OH ⁻ /+ Using Metrohm Titrando," Rev/Mod I-1, Advanced Technologies and Laboratories International, Inc., Richland, Washington.
Total carbon (combustion-coulometry)	LA-344-105, "Determination of Carbon in Solutions by Combustion and Coulometry," Rev/Mod J-0, Advanced Technologies and Laboratories International, Inc., Richland, Washington.

The quality assurance data 'flags' in the right-most column of the data summary tables are defined as follows:

J	Estimated
U	Less than detection limit

Table D-1. Tank 241-AW-106 Boildown Chemical Analysis Results for all Submitted Liquid Samples (20 sheets)

AW106 BLUN 2013
Data Summary Report

Sample Group: 20130122

Customer Group or SDG Number:

Segment Portion: Tank Composite (Supernatant Liquid)

Parent Sample Number: S131001219

Sample	N	RE CAS #	Analyte	Unit	STD %	Blank	Result	Duplicate	Average	RPD %	Spk Rec %	Unit Limit	Crit. Val %	Qual Flags
Anions and Small Organic Acids														
B19T001220		18004-49-0	Fluoride	ugm/L	30.0	<0.01E+00	1.12E+03	n/a	n/a	n/a	n/a	25.0	n/a	
S13T001720		000-14-8	Cyanide	ugm/L	30.4	<0.01E+00	<0.01	n/a	n/a	n/a	n/a	14.0	n/a	U
B19T001220		71-30-1	Acetate	ugm/L	33.4	<0.04E+00	<0.01	n/a	n/a	n/a	n/a	90.0	n/a	U
B19T001220		12311-07-0	Formate	ugm/L	37.0	<0.01E+00	1.21E+03	n/a	n/a	n/a	n/a	70.0	n/a	U
S13T001720		10007-00-5	Chloride	ugm/L	40.2	0.0110	1.69E+03	n/a	n/a	n/a	n/a	150	n/a	
B19T001220		14190-03-0	Nitrate	ugm/L	104	<0.0100	3.82E+04	n/a	n/a	n/a	n/a	285	n/a	
S13T001720		4408-70-2	Sulfate	ugm/L	98.0	<0.0100	5.67E+03	n/a	n/a	n/a	n/a	280	n/a	
B19T001220		330-20-5	Oxalate	ugm/L	97.4	<0.0200	<0.01	n/a	n/a	n/a	n/a	145	n/a	U
B19T001220		24009-07-0	Bromide	ugm/L	37.2	<0.0050	<0.01	n/a	n/a	n/a	n/a	870	n/a	U
S13T001720		14297-05-1	Nitrite	ugm/L	95.5	<0.0100	1.01E+03	n/a	n/a	n/a	n/a	110	n/a	
B19T001220		14205-11-2	Phosphite	ugm/L	30.5	<0.0100	2.03E+03	n/a	n/a	n/a	n/a	300	n/a	U
DENSITY														
S13T001721			Density	g/ml	99.40	n/a	1.245	1.245	1.250	0.0100	n/a	1.0000-1.00	n/a	
ICP-OES/MS Metals														
B19T001221		7429-90-6	Aluminum	ugm/L	30.0	<0.00E+00	5.87E+03	5.80E+03	5.87E+03	0.0301	92.4	12.0	n/a	
S13T001721		7440-37-2	Arsenic	ugm/L	38.0	<0.00E+00	<0.01	<0.01	n/a	n/a	80.9	10.0	n/a	U
B19T001221		7440-39-3	Barium	ugm/L	100	<1.00E+00	<0.01	<0.01	n/a	n/a	98.4	200	n/a	U
S13T001721		7440-41-7	Beryllium	ugm/L	100	<1.00E+00	<0.01	<0.01	n/a	n/a	100	5.00	n/a	U
B19T001221		7440-70-3	Calcium	ugm/L	95.5	<0.0000	<0.01	<0.01	n/a	n/a	90.4	150	n/a	U
B19T001221		7440-42-9	Cadmium	ugm/L	37.0	<1.00E+00	2.81	2.82	2.82	0.107	61.1	2.00	n/a	U
S13T001721		7440-47-3	Chromium	ugm/L	100	<1.00E+00	405	404	404	0.273	80.0	2.00	n/a	
B19T001221		7440-52-1	Europium	ugm/L	100	<1.00E+00	<0.01	<0.01	n/a	n/a	60.0	2.00	n/a	U
S13T001721		7439-82-0	Iron	ugm/L	100	<0.0100	47.1	47.9	47.0	0.05	104	20.0	n/a	
B19T001221		7440-05-7	Hydrogen	ugm/L	98.0	<0.0200	4.42E+03	4.42E+03	4.42E+03	0.0138	90.0	40.0	n/a	
B19T001221		7439-97-0	Lanthanum	ugm/L	104	<1.00E+00	<0.01	<0.01	n/a	n/a	10.0	200	n/a	U
S13T001721		7439-98-2	Lithium	ugm/L	100	<1.00E+00	<0.01	<0.01	n/a	n/a	100	5.00	n/a	U
B19T001221		7439-95-7	Molybdenum	ugm/L	90.0	<1.00E+00	22.0	22.0	22.0	0.0092	90.0	200	n/a	

Table D-1. Tank 241-AW-106 Boildown Chemical Analysis Results for all Submitted Liquid Samples (20 sheets)

AW106 BLUN 2013
Data Summary Report

Sample Group: 20130122

Customer Group or SDG Number:

Segment Portion: Tank Composite (Supernatant Liquid)

Parent Sample Number: S131001219

Sample	ID	Ref	CAS #	Analyte	Unit	STD %	Blank	Result	Duplicate	Average	STD %	Spk Rec %	Det Limit	Cor Lim %	Qual Flag
ICP-OES Analysis															
S131001221		7440-77-8		Sodium	ug/mL	99.5	<0.0400	1.21E+05	1.21E+05	1.21E+05	0.470	99.0	0.00	n/a	
S131001221		7440-02-0		Nickel	ug/mL	100	<1.00E-03	0.10	0.10	0.10	1.31	99.1	0.00	n/a	
S131001221		7723-14-0		Phosphorus	ug/mL	99.1	<0.001+03	0.00	0.00	0.00	0.910	99.0	0.00	n/a	
S131001221		7439-92-1		Lithium	ug/mL	100	<0.00E-03	<12.0	<12.0	n/a	n/a	101	12.0	n/a U	
S131001221		7704-81-0		Borax	ug/mL	100	<5.00E-03	2.17E+08	2.10E+08	2.14E+08	0.777	102	10.0	n/a	
S131001221		7703-49-2		Telexium	ug/mL	99.0	<0.00E-03	<12.0	<12.0	n/a	n/a	99.0	12.0	n/a U	
S131001221		7440-21-3		Silicon	ug/mL	100	<0.00E-03	50.0	50.0	50.0	0.34	104	10.0	n/a J	
S131001221		7440-34-8		Strontium	ug/mL	100	<0.00E-03	<4.00	<4.00	n/a	n/a	99.0	4.00	n/a U	
S131001221		7440-32-8		Titanium	ug/mL	97.0	<1.00E-03	<2.00	<2.00	n/a	n/a	97.0	2.00	n/a U	
S131001221		7103-02-0		Thallium	ug/mL	97.0	<0.00E-03	<12.0	<12.0	n/a	n/a	99.0	12.0	n/a U	
S131001221		7440-65-8		Zinc	ug/mL	100	<4.00E-03	<0.00	<0.00	n/a	n/a	99.0	0.00	n/a U	
S131001221		7440-07-7		Bromine	ug/mL	99.0	<1.00E-03	<2.00	2.00	n/a	n/a	104	2.00	n/a U	
CHN by Polyscience															
S131001221		41099-010-0		Hydrogen	ug/mL	99.0	<0.00	1.01E+04	1.00E+04	1.00E+04	1.35	99.0	0.00	n/a	
TIC/TOC by Jeld Remittor															
S131001220		102		Total inorganic carbon	ug/mL	100	<7.00	8.56E+03	8.10E+03	8.33E+03	7.27	102	15.0	n/a	
S131001220		TOC		Total organic carbon	ug/mL	99.1	<20.0	1.38E+03	1.30E+03	1.34E+03	0.07	99.0	1.00	n/a	
Total Carbon by Fumacon															
S131001220		TC		Total carbon	ug/mL	100	10.0	7.58E+03	7.58E+03	7.58E+03	4.75	99.0	1.00	n/a	

Parent Sample Number: S13T001225

Sample	ID	Ref	CAS #	Analyte	Unit	STD %	Blank	Result	Duplicate	Average	STD %	Spk Rec %	Det Limit	Cor Lim %	Qual Flag
Anions and Small Organic Anions															
S131001224		10099-13-8		Fluoride	ug/mL	99.0	<1.00E-03	1.86E+03	n/a	n/a	n/a	n/a	24.0	n/a	
S131001224		999-14-0		Glycolate	ug/mL	91.0	<0.07E-03	7.10	n/a	n/a	n/a	n/a	1.11	n/a J	
S131001224		71-53-1		Acetate	ug/mL	91.4	<6.04E-03	7.17	n/a	n/a	n/a	n/a	00.0	n/a J	
S131001224		122-11-67-8		Formate	ug/mL	99.0	<4.00E-03	1.57E+03	n/a	n/a	n/a	n/a	70.0	n/a J	
S131001224		10099-13-8		Chloride	ug/mL	99.0	<0.00E-03	2.43E+03	n/a	n/a	n/a	n/a	150	n/a	

Table D-1. Tank 241-AW-106 Boildown Chemical Analysis Results for all Submitted Liquid Samples (20 sheets)

AW106 BLDN 2013
Data Summary Report

Sample Group: 20130122

Customer Group or SDG Number:

Segment Portion: Tank Composite (Supernatant Liquid)

Parent Sample Number: S131001225

Sample	R	Ref	CAS #	Analyte	Unit	STD %	Blank	Revised	Duplicate	Average	RSD %	Spk Rec %	Det Limit	Coll br %	Qual Flag
Anions and Small Organic Acids															
S131001231		1470-03-0		Nitrate	ug/mL	102	<0.0102	5.00E+01	n/a	n/a	n/a	n/a	288	n/a	
S131001234		14808-70-8		Sulfate	ug/mL	85.7	<0.0107	7.78E+03	n/a	n/a	n/a	n/a	790	n/a	
S131001234		107-70-5		Chloride	ug/mL	97.0	<0.0231	7.03	n/a	n/a	n/a	n/a	346	n/a J	
S131001231		24609-07-0		Resorcinol	ug/mL	98.5	<0.0883	<473	n/a	n/a	n/a	n/a	870	n/a I	
S131001234		14795-45-0		Nitrite	ug/mL	94.0	<0.0208	1.00E+05	n/a	n/a	n/a	n/a	312	n/a	
S131001234		14205-44-2		Phosphate	ug/mL	96.1	<0.0167	<493	n/a	n/a	n/a	n/a	236	n/a U	
CATIONS															
S131001231		Conc'd		Conc'd	g/mL	93.42	n/a	1.001	n/a	n/a	n/a	n/a	1.00E+03	n/a	
ICP-RCA Metals															
S131001234		7429-90-5		Aluminum	ug/mL	95.5	<6.00E-03	7.00E+03	n/a	n/a	n/a	n/a	12.0	n/a	
S131001231		7440-88-2		Arsenic	ug/mL	90.2	<0.00E-03	<10.0	n/a	n/a	n/a	n/a	10.0	n/a U	
S131001234		7440-39-0		Barium	ug/mL	103	<1.00E-03	<7.00	n/a	n/a	n/a	n/a	7.00	n/a I	
S131001234		7440-41-7		Beryllium	ug/mL	102	<1.00E-03	<2.00	n/a	n/a	n/a	n/a	2.00	n/a U	
S131001231		7440-70-3		Calcium	ug/mL	98.5	<0.0803	<163	n/a	n/a	n/a	n/a	1.60	n/a I	
S131001234		7440-42-4		Cadmium	ug/mL	97.0	<1.00E-03	3.14	n/a	n/a	n/a	n/a	2.00	n/a J	
S131001231		7440-47-3		Chromium	ug/mL	101	<1.00E-03	5.91	n/a	n/a	n/a	n/a	2.00	n/a	
S131001234		7440-50-1		Copper	ug/mL	103	<1.00E-03	<2.00	n/a	n/a	n/a	n/a	2.00	n/a I	
S131001231		7440-80-0		Iron	ug/mL	103	<0.0103	40.1	n/a	n/a	n/a	n/a	20.0	n/a J	
S131001234		7440-02-7		Potassium	ug/mL	80.7	<0.0203	5.70E+03	n/a	n/a	n/a	n/a	40.0	n/a	
S131001234		7429-91-0		Lanthanum	ug/mL	104	<1.00E-03	<2.00	n/a	n/a	n/a	n/a	2.00	n/a U	
S131001231		7429-92-2		Lithium	ug/mL	105	<1.00E-03	<2.00	n/a	n/a	n/a	n/a	2.00	n/a I	
S131001234		7439-92-7		Molybdenum	ug/mL	98.0	<1.00E-03	20.8	n/a	n/a	n/a	n/a	2.00	n/a	
S131001231		7440-22-5		Sodium	ug/mL	90.2	<0.0103	1.40E+05	n/a	n/a	n/a	n/a	80.0	n/a	
S131001234		7440-02-0		Nickel	ug/mL	107	<1.00E-03	27.5	n/a	n/a	n/a	n/a	2.00	n/a	
S131001234		7772-14-0		Phosphorus	ug/mL	90.1	<5.00E-03	403	n/a	n/a	n/a	n/a	5.00	n/a	
S131001234		7439-92-1		Lead	ug/mL	104	<0.00E-03	<12.0	n/a	n/a	n/a	n/a	12.0	n/a U	
S131001231		7702-81-0		Sulfur	ug/mL	107	<5.00E-03	2.62E+03	n/a	n/a	n/a	n/a	10.0	n/a	

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LAB-RPT-13-00003 R0
Attachment D

Table D-1. Tank 241-AW-106 Boildown Chemical Analysis Results for all Submitted Liquid Samples (20 sheets)

AW106 BLDN 2013
Data Summary Report

Sample Group: 20130122

Customer Group or SDG Number:

Segment Portion: Tank Composite (Supernatant Liquid)

Parent Sample Number: S13T001225

Sample#	R	AE	CAS#	Analyte	Unit	STD %	Blank	Result	Duplicate	Average	RPD %	Spk Rec %	Det Limb	Conc Limb	Qual Flag
ICP-ORCA Metals															
S13T001234			7782-10-2	Selenium	ug/mL	88.0	<0.01E+00	<0.00	n/a	n/a	n/a	n/a	12.0	n/a	L
S13T001234			7440-20-0	Silver	ug/mL	100	<0.00E+00	1.00	n/a	n/a	n/a	n/a	10.0	n/a	L
S13T001234			7440-24-0	Strontium	ug/mL	970	<0.01E+00	<0.00	n/a	n/a	n/a	n/a	1.00	n/a	L
S13T001234			7440-32-6	Titanium	ug/mL	91.0	<0.00E+00	<0.00	n/a	n/a	n/a	n/a	2.00	n/a	L
S13T001234			7440-20-0	Vanadium	ug/mL	67.0	<0.00E+00	<0.00	n/a	n/a	n/a	n/a	10.0	n/a	L
S13T001234			7440-20-0	Zinc	ug/mL	970	<0.01E+00	<0.00	n/a	n/a	n/a	n/a	8.00	n/a	L
S13T001234			7440-27-7	Zirconium	ug/mL	80.0	<0.01E+00	<0.00	n/a	n/a	n/a	n/a	2.00	n/a	L
OIL by Tot. Titration															
S13T001234			HYDROXIDE	Hydroxide	ug/mL	88.0	<0.00E+00	1.00E+00	n/a	n/a	n/a	n/a	50.0	n/a	L
TIC/TOC by Acid Persulfate															
S13T001234			TIC	Total Inorganic carbon	ug/mL	970	<0.00E+00	7.00E+00	n/a	n/a	n/a	n/a	30.0	n/a	L
S13T001234			TOC	Total organic carbon	ug/mL	89.0	<0.00E+00	1.00E+00	n/a	n/a	n/a	n/a	10.0	n/a	L

Parent Sample Number: S13T001226

Sample#	R	AE	CAS#	Analyte	Unit	STD %	Blank	Result	Duplicate	Average	RPD %	Spk Rec %	Det Limb	Conc Limb	Qual Flag
Anions and Total Organic Acids															
S13T001235			10784-48-8	Fluoride	ug/mL	90.0	<0.01E+00	1.00E+00	n/a	n/a	n/a	n/a	24.0	n/a	L
S13T001235			665-14-8	Glycolic acid	ug/mL	88.0	<0.01E+00	8.00	n/a	n/a	n/a	n/a	14.0	n/a	L
S13T001235			71-50-1	Acetate	ug/mL	90.0	<0.00E+00	0.00	n/a	n/a	n/a	n/a	90.0	n/a	L
S13T001235			12311-07-3	Formate	ug/mL	67.0	<0.01E+00	1.00E+00	n/a	n/a	n/a	n/a	70.0	n/a	L
S13T001235			10707-05-5	Chloride	ug/mL	88.0	<0.01E+00	2.00E+00	n/a	n/a	n/a	n/a	15.0	n/a	L
S13T001235			14197-05-3	Nitrate	ug/mL	100	<0.01E+00	6.00E+00	n/a	n/a	n/a	n/a	20.0	n/a	L
S13T001235			14308-04-8	Sulfate	ug/mL	88.0	<0.01E+00	8.00E+00	n/a	n/a	n/a	n/a	20.0	n/a	L
S13T001235			822-70-8	Oxalate	ug/mL	91.0	<0.00E+00	0.00	n/a	n/a	n/a	n/a	34.0	n/a	L
S13T001235			24956-87-9	Bromide	ug/mL	67.0	<0.00E+00	<0.00	n/a	n/a	n/a	n/a	87.0	n/a	L
S13T001235			14707-50-8	Nitrite	ug/mL	88.0	<0.01E+00	2.00E+00	n/a	n/a	n/a	n/a	31.0	n/a	L
S13T001235			14707-44-7	Phosphate	ug/mL	90.0	<0.01E+00	<0.00	n/a	n/a	n/a	n/a	20.0	n/a	L
ICP-ORCA															

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LAB-RPT-13-00003 R0
Attachment D

Table D-1. Tank 241-AW-106 Boildown Chemical Analysis Results for all Submitted Liquid Samples (20 sheets)

AW106 RI DN 2013
Data Summary Report

Sample Group: 20130122

Customer Group or SDC Number:

Segment Portion: Tank Composite (Supernatant Liquid)

Parent Sample Number: S41T001226

Sample	R	Alt	CAS#	Analyte	Unit	STD %	Blank	Result	Duplicate	Average	RPD %	Spk Rec %	Det Limit	Cnt Err %	Qual Flags
DENSITY															
S41T001226			Density	Density	g/ml	99.43	n/a	1.217	n/a	n/a	n/a	n/a	1.0000 CA	n/a	
ICP-BCRA Metals															
S41T001226			7440-00-6	Aluminum	ug/ml	95.5	<5.00E-03	7.55E+03	n/a	n/a	n/a	n/a	12.0	n/a	
S41T001226			7440-20-2	Arsenic	ug/mL	99.2	<5.00E-03	<10.0	n/a	n/a	n/a	n/a	10.0	n/a U	
S41T001226			7440-30-8	Barium	ug/mL	101	<1.00E-08	<2.00	n/a	n/a	n/a	n/a	2.00	n/a U	
S41T001226			7440-41-7	Beryllium	ug/ml	97.0	<1.00E-03	<7.00	n/a	n/a	n/a	n/a	2.00	n/a LI	
S41T001226			7440-70-2	Calcium	ug/mL	99.5	<0.0000	<100	n/a	n/a	n/a	n/a	100	n/a U	
S41T001226			7440-13-0	Cadmium	ug/mL	97.0	<1.00E-08	2.01	n/a	n/a	n/a	n/a	2.00	n/a U	
S41T001226			7440-47-3	Chromium	ug/ml	91.0	<1.00E-03	855	n/a	n/a	n/a	n/a	2.00	n/a	
S41T001226			7440-29-1	Europram	ug/mL	100	<1.00E-09	<2.00	n/a	n/a	n/a	n/a	2.00	n/a U	
S41T001226			7440-50-6	Iron	ug/ml	973	<0.0100	57.8	n/a	n/a	n/a	n/a	20.0	n/a U	
S41T001226			7440-39-1	Fluorine	ug/mL	90.7	<0.0000	5.73E+02	n/a	n/a	n/a	n/a	40.0	n/a	
S41T001226			7440-21-0	Lanthanum	ug/mL	101	<1.00E-08	<2.00	n/a	n/a	n/a	n/a	2.00	n/a U	
S41T001226			7439-92-2	Lithium	ug/ml	975	<1.00E-03	<7.00	n/a	n/a	n/a	n/a	2.00	n/a LI	
S41T001226			7439-98-1	Molybdenum	ug/mL	90.0	<1.00E-09	30.8	n/a	n/a	n/a	n/a	2.00	n/a	
S41T001226			7440-23-8	Sodium	ug/ml	96.0	<0.0100	1.55E+04	n/a	n/a	n/a	n/a	80.0	n/a	
S41T001226			7440-02-0	Nickel	ug/mL	100	<1.00E-03	28.5	n/a	n/a	n/a	n/a	2.00	n/a	
S41T001226			7723-14-0	Phosphorus	ug/mL	90.1	<3.00E-08	901	n/a	n/a	n/a	n/a	0.00	n/a	
S41T001226			7439-92-1	Lead	ug/ml	974	<5.00E-03	<12.0	n/a	n/a	n/a	n/a	12.0	n/a LI	
S41T001226			7704-34-9	Sulfur	ug/mL	100	<5.00E-03	2.07E+02	n/a	n/a	n/a	n/a	10.0	n/a	
S41T001226			7782-10-2	Selenium	ug/mL	90.0	<1.00E-08	<12.0	n/a	n/a	n/a	n/a	12.0	n/a U	
S41T001226			7440-21-8	Silicon	ug/ml	970	<5.00E-03	35.0	n/a	n/a	n/a	n/a	10.0	n/a U	
S41T001226			7440-24-6	Srrium	ug/mL	100	<2.00E-09	<4.00	n/a	n/a	n/a	n/a	4.00	n/a U	
S41T001226			7440-32-0	Titanium	ug/ml	97.8	<1.00E-03	<7.00	n/a	n/a	n/a	n/a	2.00	n/a LI	
S41T001226			7440-28-0	Vanadium	ug/mL	91.3	<5.00E-03	<12.0	n/a	n/a	n/a	n/a	10.0	n/a U	
S41T001226			7440-28-6	Zinc	ug/mL	100	<1.00E-08	<3.00	n/a	n/a	n/a	n/a	8.00	n/a U	
S41T001226			7440-07-7	Zirconium	ug/mL	90.2	<1.00E-03	<2.00	n/a	n/a	n/a	n/a	2.00	n/a U	

OH by Pol Titration

Table D-1. Tank 241-AW-106 Boildown Chemical Analysis Results for all Submitted Liquid Samples (20 sheets)

AW106 RI DN 2013
Data Summary Report

Sample Group: 20130122

Customer Group or SDG Number:

Segment Portion: Tank Composite (Supernatant Liquid)

Parent Sample Number: S131001226

Sample#	IT	AP	CAS#	Analyte	Unit	STD %	Blank	Result	Duplicate	Average	RPD %	Spk Rec %	Det Limit	Conc Lim %	Qual Flags
S131001226			HYDROXIDE	Hydroxide	ug/mL	85.8	<0.22	1.58E+04	n/a	n/a	n/a	n/a	100	n/a	
TIC/TOC by Acid Peroxide															
S131001226			TIC	Total Inorganic carbon	ug/mL	101	<0.00	0.84E+03	n/a	n/a	n/a	n/a	25.0	n/a	
S131001226			TOC	Total organic carbon	ug/mL	84.1	<0.00	1.87E+03	n/a	n/a	n/a	n/a	100	n/a	

Parent Sample Number: S131001227

Sample#	IT	AP	CAS#	Analyte	Unit	STD %	Blank	Result	Duplicate	Average	RPD %	Spk Rec %	Det Limit	Conc Lim %	Qual Flags
Anions and Small Organic Acids															
S131001226			13984-46-8	Fluoride	ug/mL	65.0	<0.51E-03	1.88E+03	n/a	n/a	n/a	n/a	24.0	n/a	
S131001226			556-14-8	Glycine	ug/mL	95.4	<0.00E+00	871	n/a	n/a	n/a	n/a	11.1	n/a J	
S131001226			71-02-1	Acetate	ug/mL	63.4	<0.04E-03	912	n/a	n/a	n/a	n/a	50.0	n/a J	
S131001226			12211-07-6	Formate	ug/mL	67.0	<0.07E-03	1.60E+03	n/a	n/a	n/a	n/a	70.0	n/a J	
S131001226			15851-40-6	Chloride	ug/mL	95.0	<0.01E+00	2.02E+03	n/a	n/a	n/a	n/a	150	n/a	
S131001226			14767-64-0	Nitrite	ug/mL	104	<0.01E+00	6.33E+01	n/a	n/a	n/a	n/a	28.8	n/a	
S131001226			14850-76-0	Sulfate	ug/mL	95.0	<0.01E+00	9.19E+03	n/a	n/a	n/a	n/a	100	n/a	
S131001226			538-70-0	Oxalate	ug/mL	67.4	<0.02E+00	659	n/a	n/a	n/a	n/a	81.0	n/a J	
S131001226			24959-67-4	Bromide	ug/mL	97.0	<0.05E+00	4070	n/a	n/a	n/a	n/a	07.0	n/a U	
S131001226			14767-60-8	Nitrate	ug/mL	65.0	<0.02E+00	2.20E+03	n/a	n/a	n/a	n/a	81.2	n/a	
S131001226			14265-44-2	Phosphate	ug/mL	85.0	<0.01E+00	4240	n/a	n/a	n/a	n/a	25.0	n/a U	
ULRICH V															
S131001226			Density	Density	g/mL	00.10	n/a	1.880	n/a	n/a	n/a	n/a	1.000E-03	n/a	
ICP BORAM Labs															
S131001226			7429-90-5	Aluminum	ug/mL	95.5	<0.00E+00	0.40E+03	n/a	n/a	n/a	n/a	12.0	n/a	
S131001226			7440-38-2	Arsenic	ug/mL	69.0	<0.00E-03	<0.00	n/a	n/a	n/a	n/a	10.0	n/a U	
S131001226			7183-39-3	Barium	ug/mL	101	<0.00E+01	<0.00	n/a	n/a	n/a	n/a	2.00	n/a U	
S131001226			7440-41-7	Beryllium	ug/mL	102	<0.00E-03	<0.00	n/a	n/a	n/a	n/a	2.00	n/a U	
S131001226			7183-70-2	Calcium	ug/mL	85.5	<0.00E+01	<0.00	n/a	n/a	n/a	n/a	15.0	n/a U	
S131001226			7440-43-9	Cadmium	ug/mL	97.0	<0.00E+03	3.00	n/a	n/a	n/a	n/a	2.00	n/a J	
S131001226			7183-17-3	Chromium	ug/mL	101	<0.00E+01	700	n/a	n/a	n/a	n/a	2.00	n/a	

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LAB-RPT-13-00003 R0
Attachment D

Table D-1. Tank 241-AW-106 Boildown Chemical Analysis Results for all Submitted Liquid Samples (20 sheets)

AW106 BLDN 2013
Data Summary Report

Sample Group: 20130122

Customer Group or SDG Number:

Segment Portion: Tank Composite (Supernatant Liquid)

Parent Sample Number: S13T001227

Sample#	R	Alt	CAS#	Analyte	Unit	STD %	Blank	Result	Duplicate	Average	RPD %	Spk Rec %	Det Limit	Corr Rec %	Qual Flags
ICP-MS/MS Metals															
S13T001230			7440-09-1	Barium	ug/ml	97.0	<1.00E-03	<1.00	n/a	n/a	n/a	n/a	2.00	n/a	L
S13T001230			7440-09-6	Boron	ug/mL	100	<0.0100	0.00	n/a	n/a	n/a	n/a	20.0	n/a	L
S13T001230			7440-09-1	Calcium	ug/mL	68.7	<0.0030	6.01E+03	n/a	n/a	n/a	n/a	10.0	n/a	
S13T001230			7440-01-0	Carbonium	ug/ml	97.4	<1.00E-03	<1.00	n/a	n/a	n/a	n/a	2.00	n/a	L
S13T001230			7439-92-2	Chlorine	ug/ml	100	<1.00E-03	<1.00	n/a	n/a	n/a	n/a	2.00	n/a	L
S13T001230			7439-92-7	Cobaltium	ug/mL	68.0	<1.00E-03	32.8	n/a	n/a	n/a	n/a	2.00	n/a	
S13T001230			7440-05-8	Copper	ug/ml	68.0	<0.0400	1.77E+04	n/a	n/a	n/a	n/a	60.0	n/a	
S13T001230			7440-02-0	Iron	ug/mL	100	<1.00E-03	28.4	n/a	n/a	n/a	n/a	2.00	n/a	
S13T001230			7732-14-0	Phosphorus	ug/ml	68.1	<3.00E-03	3.37	n/a	n/a	n/a	n/a	6.00	n/a	
S13T001230			7439-92-1	Lead	ug/mL	104	<6.00E-03	<12.0	n/a	n/a	n/a	n/a	12.0	n/a	L
S13T001230			7701-31-0	Sulfur	ug/mL	100	<5.00E-03	8.01E+03	n/a	n/a	n/a	n/a	10.0	n/a	
S13T001230			7702-48-2	Selenium	ug/ml	68.0	<5.00E-03	<12.0	n/a	n/a	n/a	n/a	12.0	n/a	L
S13T001230			7440-27-3	Silver	ug/mL	100	<5.00E-03	7.70	n/a	n/a	n/a	n/a	10.0	n/a	L
S13T001230			7440-29-8	Sodium	ug/ml	97.0	<2.00E-03	<1.00	n/a	n/a	n/a	n/a	1.00	n/a	L
S13T001230			7440-22-8	Titanium	ug/mL	91.8	<1.00E-03	<2.00	n/a	n/a	n/a	n/a	2.00	n/a	L
S13T001230			7440-28-0	Thallium	ug/mL	67.3	<5.00E-03	<12.0	n/a	n/a	n/a	n/a	12.0	n/a	L
S13T001230			7440-06-8	Zinc	ug/ml	91.0	<4.00E-03	<8.00	n/a	n/a	n/a	n/a	10.00	n/a	L
S13T001230			7440-07-7	Zirconium	ug/mL	68.2	<1.00E-03	<2.00	n/a	n/a	n/a	n/a	2.00	n/a	L
OH by Pot Titration															
S13T001230			Hydroxide	Hydroxide	ug/ml	68.0	<8.00	1.77E+04	n/a	n/a	n/a	n/a	50.0	n/a	
TOC/TOD by Acid Permanganate															
S13T001230			TOC	Total organic carbon	ug/mL	101	<1.00	9.23E+03	n/a	n/a	n/a	n/a	10.0	n/a	
S13T001230			TOD	Total organic carbon	ug/ml	80.1	<10.0	1.03E+04	n/a	n/a	n/a	n/a	20.0	n/a	

Parent Sample Number: S13T001228

Sample#	R	Alt	CAS#	Analyte	Unit	STD %	Blank	Result	Duplicate	Average	RPD %	Spk Rec %	Det Limit	Corr Rec %	Qual Flags
Anions and Small Organic Acids															
S13T001230			10091-18-3	Fluoride	ug/ml	68.8	<1.00E-03	1.97E+03	n/a	n/a	n/a	n/a	24.0	n/a	

NW106 DLDN 2013
Data Summary Report

Parent Sample Number: S131001228

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Table D-1. Tank 241-AW-106 Boildown Chemical Analysis Results for all Submitted Liquid Samples (20 sheets)

AW106 BLDN 2013
Data Summary Report

Sample Group: 20130122

Customer Group or SUG Number:

Segment Portion: Tank Composite (Supernatant Liquid)

Parent Sample Number: S13T001220

Sample#	R	AF	CAS#	Analyte	Unit	STD %	Blank	Result	Duplicate	Average	RPD %	Spk Rec %	Det Limit	Cal Err %	Qual Flags
ICP-ORCA Metals															
S13T001227			7440-38-2	Nickel	ug/mL	100	<1.00E+00	30.0	n/a	n/a	n/a	n/a	2.00	n/a	
S13T001227			7732-14-7	Phosphorus	ug/mL	90.1	<2.00E+00	30.0	n/a	n/a	n/a	n/a	0.00	n/a	
S13T001227			14399-92-1	Lithium	ug/mL	100	<2.00E+00	<1.00E+00	n/a	n/a	n/a	n/a	1.00	n/a	
S13T001227			7704-34-0	Cadmium	ug/mL	100	<2.00E+00	2.00E+00	n/a	n/a	n/a	n/a	10.0	n/a	
S13T001227			7782-49-2	Selenium	ug/mL	60.0	<2.00E+00	<1.00E+00	n/a	n/a	n/a	n/a	10.0	n/a	L
S13T001227			7440-21-3	Silicon	ug/mL	100	<2.00E+00	84.2	n/a	n/a	n/a	n/a	10.0	n/a	L
S13T001227			14403-26-8	Uranium	ug/mL	100	<2.00E+00	<4.00E+00	n/a	n/a	n/a	n/a	4.00	n/a	L
S13T001227			7440-32-0	Titanium	ug/mL	67.8	<1.00E+00	<2.00E+00	n/a	n/a	n/a	n/a	2.00	n/a	L
S13T001227			7440-76-0	Thallium	ug/mL	87.0	<2.00E+00	<1.00E+00	n/a	n/a	n/a	n/a	1.00	n/a	L
S13T001227			14403-20-0	Zinc	ug/mL	100	<2.00E+00	<2.00E+00	n/a	n/a	n/a	n/a	8.00	n/a	L
S13T001227			7440-57-7	Zinc Oxide	ug/mL	64.0	<1.00E+00	0.77	n/a	n/a	n/a	n/a	2.00	n/a	L
Gravimetric Titration															
S13T001227			HYDRUS-DE	Hydroxide	ug/mL	85.8	<4.00E+00	1.58E+04	n/a	n/a	n/a	n/a	10.0	n/a	
IC1102 by Acid Peroxide															
S13T001227			TIC	Total Inorganic Carbon	ug/mL	100	<2.00E+00	1.58E+04	n/a	n/a	n/a	n/a	70.0	n/a	
S13T001227			TOC	Total Organic Carbon	ug/mL	84.1	<2.00E+00	2.20E+03	n/a	n/a	n/a	n/a	20.0	n/a	

Parent Sample Number: S13T001229

Sample#	R	AF	CAS#	Analyte	Unit	STD %	Blank	Result	Duplicate	Average	RPD %	Spk Rec %	Det Limit	Cal Err %	Qual Flags
Anions and Small Organic Acids															
S13T001228			12081-85-8	Fluoride	ug/mL	60.0	<1.00E+00	0.00	n/a	n/a	n/a	n/a	21.0	n/a	
S13T001228			655-14-0	Chloride	ug/mL	85.4	<2.00E+00	7.90	n/a	n/a	n/a	n/a	14.1	n/a	L
S13T001228			7440-21-3	Silicate	ug/mL	93.4	<2.00E+00	1.00E+03	n/a	n/a	n/a	n/a	90.0	n/a	J
S13T001228			14211-40-0	Formate	ug/mL	67.0	<2.00E+00	1.00E+03	n/a	n/a	n/a	n/a	70.0	n/a	L
S13T001228			14887-00-8	Ultraviolet	ug/mL	90.0	0.0110	2.40E+03	n/a	n/a	n/a	n/a	15.0	n/a	
S13T001228			14797-01-0	Nitrite	ug/mL	100	<2.00E+00	7.10E+01	n/a	n/a	n/a	n/a	28.0	n/a	
S13T001228			11808-70-8	Sulfate	ug/mL	90.0	<2.00E+00	2.50E+03	n/a	n/a	n/a	n/a	20.0	n/a	J
S13T001228			208-10-5	Oxalate	ug/mL	67.8	<2.00E+00	<3.00E+00	n/a	n/a	n/a	n/a	3.00	n/a	L

Table D-1. Tank 241-AW-106 Boildown Chemical Analysis Results for all Submitted Liquid Samples (20 sheets)

AW106 DD DN 2013
Data Summary Report

Sample Group: 20130122

Customer Group or SDG Number:

Segment Portion: Tank Composite (Supernatant Liquid)

Parent Sample Number: S13T001229

Sample#	B	A#	CAS#	Analyte	Unit	STD %	Blank	Result	Duplicate	Average	RSD %	Spk Rec %	Det Limit	Corr Dr %	Qual Flags
Anions and Small Organic Acids															
S13T001238			7486-67-8	Bromide	ug/mL	91.2	<0.0050	<5.00	n/a	n/a	n/a	n/a	87.0	n/a	L
S13T001238			14797-55-8	Nitrate	ug/mL	68.6	<0.0050	0.00E+00	n/a	n/a	n/a	n/a	33.0	n/a	L
S13T001238			14798-18-7	Phosphate	ug/mL	98.8	<0.0050	<25.0	n/a	n/a	n/a	n/a	25.0	n/a	L
DENSITY															
S13T001238			Density	Density	g/mL	99.42	n/a	1.094	n/a	n/a	n/a	n/a	1.00E+03	n/a	L
ICP-MS/MS Metals															
S13T001238			7440-70-6	Antimony	ug/mL	68.6	<1.00E-03	0.00E+00	n/a	n/a	n/a	n/a	1.00	n/a	L
S13T001238			7440-38-2	Arsenic	ug/mL	99.2	<1.00E-03	<10.00	n/a	n/a	n/a	n/a	10.0	n/a	L
S13T001238			7440-30-3	Boron	ug/mL	87.1	<1.00E-03	<2.00	n/a	n/a	n/a	n/a	2.00	n/a	L
S13T001238			7440-41-1	Barium	ug/mL	102	<1.00E-03	<2.00	n/a	n/a	n/a	n/a	2.00	n/a	L
S13T001238			7440-70-2	Calcium	ug/mL	60.6	<0.0050	<1.00	n/a	n/a	n/a	n/a	1.00	n/a	L
S13T001238			7440-43-9	Cadmium	ug/mL	91.8	<1.00E-03	4.15	n/a	n/a	n/a	n/a	2.00	n/a	L
S13T001238			7440-17-8	Chromium	ug/mL	801	<1.00E-03	810	n/a	n/a	n/a	n/a	2.00	n/a	L
S13T001238			7440-70-1	Copper	ug/mL	87.0	<1.00E-03	<2.00	n/a	n/a	n/a	n/a	2.00	n/a	L
S13T001238			7439-89-0	Iron	ug/mL	809	<0.0100	72.0	n/a	n/a	n/a	n/a	20.0	n/a	L
S13T001238			7440-19-7	Chromium	ug/mL	80.7	<0.0050	7.10E+01	n/a	n/a	n/a	n/a	40.0	n/a	L
S13T001238			7439-97-0	Lanthanum	ug/mL	104	<1.00E-03	<2.00	n/a	n/a	n/a	n/a	2.00	n/a	L
S13T001238			7440-03-2	Lithium	ug/mL	87.6	<1.00E-03	<2.00	n/a	n/a	n/a	n/a	2.00	n/a	L
S13T001238			7440-08-7	Molybdenum	ug/mL	98.8	<1.00E-03	20.7	n/a	n/a	n/a	n/a	2.00	n/a	L
S13T001238			7440-23-5	Sodium	ug/mL	68.8	<0.0100	1.00E+00	n/a	n/a	n/a	n/a	80.0	n/a	L
S13T001238			7440-70-0	Nickel	ug/mL	100	<1.00E-03	21.0	n/a	n/a	n/a	n/a	2.00	n/a	L
S13T001238			7723-14-0	Phosphorus	ug/mL	60.1	<1.00E-03	207	n/a	n/a	n/a	n/a	0.00	n/a	L
S13T001238			7732-02-1	Lead	ug/mL	814	<0.0100	12.0	n/a	n/a	n/a	n/a	10.0	n/a	L
S13T001238			7734-24-9	Sulfur	ug/mL	100	<1.00E-03	1.10E+03	n/a	n/a	n/a	n/a	10.0	n/a	L
S13T001238			7732-10-2	Sulfuric	ug/mL	88.8	<1.00E-03	<12.0	n/a	n/a	n/a	n/a	10.0	n/a	L
S13T001238			7440-21-3	Silicon	ug/mL	87.0	<1.00E-03	32.6	n/a	n/a	n/a	n/a	10.0	n/a	L
S13T001238			7440-24-0	Silver	ug/mL	100	<2.00E-03	<4.00	n/a	n/a	n/a	n/a	4.00	n/a	L

Table D-1. Tank 241-AW-106 Boildown Chemical Analysis Results for all Submitted Liquid Samples (20 sheets)

AW106 BLDN 2013
Data Summary Report

Sample Group: 20130122

Customer Group or SDG Number:

Segment Portion: Tank Composite (Supernatant Liquid)

Parent Sample Number: S13T001229

Sample#	R	AE	Case	Analyte	Unit	STD %	Blank	Result	Duplicate	Average	RPD %	Spk Rec %	Det Limit	Crit. Br %	Qual Flags
ICP-RCRA Metals															
S13T001230			7440-32-0	Thallium	ug/mL	87.6	<1.0E-03	<1.00	n/a	n/a	n/a	n/a	2.00	n/a	L
S13T001238			7440-20-6	Indium	ug/mL	91.3	<10.0E-09	<12.0	n/a	n/a	n/a	n/a	12.0	n/a	L
S13T001238			7440-20-0	Zinc	ug/mL	87.0	<1.0E-03	<1.00	n/a	n/a	n/a	n/a	8.00	n/a	L
S13T001238			7440-57-7	Zincum	ug/mL	98.2	<10.0E-09	2.27	n/a	n/a	n/a	n/a	20.0	n/a	L
Oil by Tot. Titration															
S13T001238			HYDROXIDE	Hydroxide	ug/mL	88.8	<9.22	2.19E+04	n/a	n/a	n/a	n/a	50.0	n/a	
T.C./T.O.C by Acid Persulfate															
S13T001230			T.C.	Total Inorganic Carbon	ug/mL	87.0	<7.30	1.11E+04	n/a	n/a	n/a	n/a	20.0	n/a	
S13T001238			T.O.C	Total Organic Carbon	ug/mL	89.1	<20.0	1.67E+05	n/a	n/a	n/a	n/a	20.0	n/a	
Parent Sample Number: S13T001239															
Sample#	R	AE	Case	Analyte	Unit	STD %	Blank	Result	Duplicate	Average	RPD %	Spk Rec %	Det Limit	Crit. Br %	Qual Flags
Anions and Small Organic Acids															
S13T001230			14094-18-2	Fluoride	ug/mL	88.3	<1.0E-03	582	518	550	5.80	85.7	24.0	n/a	
S13T001239			889-14-8	Glycolate	ug/mL	94.8	<6.0E-03	0.82	0.73	0.40	2.46	97.8	14.1	n/a	L
S13T001230			71-80-1	Acetate	ug/mL	82.6	<5.0E-03	1.24E+03	1.27E+03	1.26E+03	1.84	85.1	80.0	n/a	L
S13T001239			12271-97-5	Formate	ug/mL	98.9	<6.0E-03	2.13E+02	2.04E+02	2.09E+02	4.40	101	20.0	n/a	L
S13T001230			10887-00-3	Chloride	ug/mL	80.1	0.0110	3.80E+03	3.02E+03	3.31E+03	0.501	87.0	100	n/a	
S13T001239			14797-85-3	Nitrate	ug/mL	101	<0.0162	6.51E+04	6.51E+04	6.54E+04	0.576	108	20.0	n/a	
S13T001230			14308-70-3	Sulfate	ug/mL	80.3	<0.0187	2.80E+03	3.10E+03	3.00E+03	10.2	85.1	280	n/a	L
S13T001230			333-70-8	Oxalate	ug/mL	86.6	<0.0231	<0.46	<0.48	n/a	n/a	100	34.0	n/a	L
S13T001230			24006-07-3	Bromide	ug/mL	80.8	<0.0080	<870	<870	n/a	n/a	87.0	870	n/a	L
S13T001230			14702-00-3	Nitrite	ug/mL	84.4	<0.0230	2.58E+03	2.68E+03	2.63E+03	3.0423	81.1	38.0	n/a	
S13T001239			14798-44-7	Phosphate	ug/mL	95.5	<0.0187	<250	<250	n/a	n/a	95.5	20.0	n/a	L
DENSITY															
S13T001230			Density	Density	g/mL	88.42	n/a	1.302	n/a	n/a	n/a	n/a	1.000E-03	n/a	
ICP-RCRA Metals															
S13T001239			7429-90-5	Vanadium	ug/mL	95.5	<5.0E-03	1.10E+04	1.20E+04	1.15E+04	11.5	n/a	12.0	n/a	

Table D-1. Tank 241-AW-106 Boildown Chemical Analysis Results for all Submitted Liquid Samples (20 sheets)

AW106 DI DN 2013

Data Summary Report

Sample Group: 20130122

Customer Group or SDC Number:

Segment Portion: Tank Composite (Supernatant Liquid)

Parent Sample Number: 513T001230

Sample	R	As	Q18.2	Analyte	Unit	STD %	Blank	Result	Duplicate	Average	RPD %	Spk Res %	Det Unit	Conc Fr %	Qual Flag
ICP RCRA Metals															
513T001230			7110.35.2	Arsenic	ug/ml	48.2	<0.00E+00	<0.00	0.10	n/a	n/a	n/a	0.00	n/a U	
513T001230			7440.95.0	Barium	ug/ml	101	<1.00E+03	<2.00	<2.00	n/a	n/a	n/a	2.00	n/a U	
513T001230			7110.35.2	Beryllium	ug/ml	102	<1.00E+03	<2.00	<2.00	n/a	n/a	n/a	2.00	n/a U	
513T001230			7440.70.0	Calcium	ug/ml	90.0	<0.00E+03	<1.00	<1.00	n/a	n/a	n/a	1.00	n/a U	
513T001230			7440.45.0	Cadmium	ug/ml	07.0	<1.00E+03	4.00	0.00	0.00	0.00	n/a	2.00	n/a J	
513T001230			7440.47.0	Chromium	ug/ml	103	<1.00E+03	0.10	0.00	0.00	0.00	n/a	2.00	n/a	
513T001230			7440.50.0	Copper	ug/ml	100	<1.00E+03	<2.00	<2.00	n/a	n/a	n/a	2.00	n/a U	
513T001230			7150.80.0	Iron	ug/ml	105	<0.01E+03	0.00	0.00	0.00	0.00	n/a	2.00	n/a J	
513T001230			7440.40.0	Manganese	ug/ml	48.2	<0.01E+03	0.00	0.00	0.00	0.00	n/a	2.00	n/a	
513T001230			7150.01.0	Mercury	ug/ml	101	<1.00E+03	<2.00	0.00	n/a	n/a	n/a	2.00	n/a U	
513T001230			7439.87.0	Nickel	ug/ml	104	<1.00E+03	<2.00	<2.00	n/a	n/a	n/a	2.00	n/a U	
513T001230			7439.95.0	Molybdenum	ug/ml	90.0	<1.00E+03	0.00	0.00	0.00	0.00	n/a	2.00	n/a	
513T001230			7440.35.0	Sodium	ug/ml	06.0	<0.04E+03	0.00E+00	0.00E+00	0.00E+00	0.00	n/a	2.00	n/a	
513T001230			7440.40.0	Nickel	ug/ml	100	<1.00E+03	0.00	0.00	0.00	0.00	n/a	2.00	n/a	
513T001230			7728.11.0	Phosphorus	ug/ml	00.1	<0.00E+03	0.00	0.00	0.00	0.00	n/a	0.00	n/a	
513T001230			7439.87.0	Nickel	ug/ml	104	<0.00E+03	<1.00	<1.00	n/a	n/a	n/a	2.00	n/a U	
513T001230			7704.34.0	Sulfur	ug/ml	100	<0.00E+03	1.00E+03	1.00E+03	1.00E+03	1.41	n/a	10.0	n/a	
513T001230			7704.40.0	Tellurium	ug/ml	08.0	<0.00E+03	<1.00	<1.00	n/a	n/a	n/a	2.00	n/a U	
513T001230			7440.21.0	Silicon	ug/ml	102	<0.00E+03	0.00	0.00	0.00	0.00	n/a	10.0	n/a J	
513T001230			7440.34.0	Strontium	ug/ml	100	<0.00E+03	<1.00	<1.00	n/a	n/a	n/a	1.00	n/a U	
513T001230			7440.25.0	Titanium	ug/ml	90.0	<1.00E+03	<2.00	<2.00	n/a	n/a	n/a	2.00	n/a U	
513T001230			7110.35.0	Thallium	ug/ml	07.0	<0.00E+03	<1.00	<1.00	n/a	n/a	n/a	12.0	n/a U	
513T001230			7440.40.0	Tin	ug/ml	100	<0.00E+03	<0.00	<0.00	n/a	n/a	n/a	0.00	n/a U	
513T001230			7440.86.0	Zinc	ug/ml	08.0	<1.00E+03	0.00	<2.00	n/a	n/a	n/a	2.00	n/a J	
CH-By PoL Titration															
513T001230			HYDROXIDE	Hydroxide	ug/ml	00.0	0.00	0.00E+04	0.00E+04	0.00E+04	0.00	0.00	0.00E+04	n/a	
TIC/TOC by Acid Percolate															

Table D-1. Tank 241-AW-106 Boildown Chemical Analysis Results for all Submitted Liquid Samples (20 sheets)

AW106 BIL DN 2013
Data Summary Report

Sample Group: 20130122

Customer Group or SUG Number:

Segment Portion: Tank Composite (Supernatant Liquid)

Parent Sample Number: S13T001230

Sample#	R	AK	CRSE	Analyte	Unit	STD %	Blank	Result	Duplicate	Average	RPD %	Spk Rec %	Det Limit	Crit Err %	Qual Flags
TOC/TED by Acid Oxidation															
S13T001230			TC	Total inorganic carbon	ugm/L	98.0	<0.00	8.49E+03	9.02E+03	8.49E+03	0.77%	100	70.0	n/a	
S13T001230			TOC	Total organic carbon	ugm/L	86.7	<0.00	2.10E+03	2.03E+03	2.06E+03	2.43	85.0	20.0	n/a	
Total Carbon by Potassium															
S13T001230			TC	Total carbon	ugm/L	60.2	<0.00	1.28E+04	1.23E+04	1.20E+04	3.08	87.0	80.0	n/a	
Parent Sample Number: S13T001233															
Sample#	R	AK	CRSE	Analyte	Unit	STD %	Blank	Result	Duplicate	Average	RPD %	Spk Rec %	Det Limit	Crit Err %	Qual Flags
Anions and Small Organic Acids															
S13T001242			10784-48-8	Fluoride	ugm/L	90.2	<0.01E-03	0.99	n/a	n/a	n/a	n/a	24.2	n/a	
S13T001242			665-11-8	Glycolate	ugm/L	61.8	<0.37E-03	0.07	n/a	n/a	n/a	n/a	1.1	n/a	J
S13T001240			71-50-1	Acetate	ugm/L	92.6	<0.14E-03	1.45E-03	n/a	n/a	n/a	n/a	46.5	n/a	I
S13T001242			12311-47-3	Formate	ugm/L	90.9	<4.07E-03	2.49E+03	n/a	n/a	n/a	n/a	70.0	n/a	J
S13T001242			10687-00-5	Chloride	ugm/L	66.1	<0.01E-03	4.73E+03	n/a	n/a	n/a	n/a	15.0	n/a	
S13T001240			14787-85-3	Nitrite	ugm/L	9.6	<0.01E-03	1.03E-03	n/a	n/a	n/a	n/a	2.00	n/a	
S13T001242			14508-79-5	Sulfate	ugm/L	90.3	<0.01E-03	2.02E+03	n/a	n/a	n/a	n/a	28.0	n/a	J
S13T001242			332-70-8	Oxalate	ugm/L	66.6	<0.02E-03	<0.00	n/a	n/a	n/a	n/a	3.65	n/a	L
S13T001240			24956-45-4	Iodate	ugm/L	98.0	<0.05E-03	43.91	n/a	n/a	n/a	n/a	87.0	n/a	L
S13T001242			14797-09-5	Nitrate	ugm/L	94.4	<0.02E-03	2.78E+03	n/a	n/a	n/a	n/a	31.2	n/a	
S13T001242			14798-18-2	Phosphate	ugm/L	66.6	<0.01E-03	<0.00	n/a	n/a	n/a	n/a	25.0	n/a	L
DENSITY															
S13T001242			Density	Density	g/ml	86.42	n/a	1.000	n/a	n/a	n/a	n/a	1.000E+00	n/a	
ICP-MS/AA Metals															
S13T001242			7429-90-5	Aluminum	ugm/L	90.5	<0.00E-03	1.40E+04	n/a	n/a	n/a	n/a	12.0	n/a	
S13T001242			7440-20-2	Antimony	ugm/L	60.2	<0.00E-03	<0.00	n/a	n/a	n/a	n/a	10.0	n/a	U
S13T001242			7440-30-5	Barium	ugm/L	90.1	<1.07E-03	47.00	n/a	n/a	n/a	n/a	2.00	n/a	L
S13T001242			7440-41-7	Beryllium	ugm/L	10.2	<0.00E-03	47.00	n/a	n/a	n/a	n/a	2.00	n/a	U
S13T001242			7440-50-2	Calcium	ugm/L	66.6	<0.08E-03	<0.00	n/a	n/a	n/a	n/a	10.0	n/a	U
S13T001242			7440-19-0	Cadmium	ugm/L	67.0	<0.00E-03	0.70	n/a	n/a	n/a	n/a	2.00	n/a	J

Table D-1. Tank 241-AW-106 Boildown Chemical Analysis Results for all Submitted Liquid Samples (20 sheets)

AW106 BLDN 2013
Data Summary Report

Sample Group: 20130122

Customer Group or SDG Number:

Segment Portion: Tank Composite (Supernatant Liquid)

Parent Sample Number: S13T001233

Sample#	R	Alt	Case	Analyte	Unit	STD %	Blank	Recall	Duplicate	Average	RPD %	Sys. Rec %	Det Limit	Cr. L. Br. %	Qual Flags
ICP-MS/MS Metals															
S13T301240			7440-47-3	Chromium	ug/mL	87%	<1.00E-03	1.04E+03	n/a	n/a	n/a	n/a	2.00	n/a	
S131301240			7440-52-1	Copper	ug/mL	100	<1.00E-03	<2.00	n/a	n/a	n/a	n/a	2.00	n/a	U
S13T301242			7439-92-0	Iron	ug/mL	103	<0.0100	95.0	n/a	n/a	n/a	n/a	20.0	n/a	
S131301240			7440-10-7	Platinum	ug/mL	90.7	<0.00200	9.20E+02	n/a	n/a	n/a	n/a	40.0	n/a	
S131301240			7439-97-0	Lanthanum	ug/mL	101	<1.00E-03	<2.00	n/a	n/a	n/a	n/a	2.00	n/a	U
S13T301242			7439-98-2	Lithium	ug/mL	87%	<1.00E-03	<2.00	n/a	n/a	n/a	n/a	2.00	n/a	U
S13T301240			7439-96-7	Molybdenum	ug/mL	96.0	<1.00E-03	40.7	n/a	n/a	n/a	n/a	2.00	n/a	
S13T301240			7440-23-5	Sodium	ug/mL	90.0	<0.0400	2.00E+02	n/a	n/a	n/a	n/a	80.0	n/a	
S13T301240			7440-10-6	Nickel	ug/mL	97%	<1.00E-03	40.8	n/a	n/a	n/a	n/a	2.00	n/a	
S131301240			7723-14-0	Phosphorus	ug/mL	90.7	<3.00E-03	328	n/a	n/a	n/a	n/a	0.00	n/a	
S13T301240			7440-10-1	Lead	ug/mL	87%	<5.00E-03	<10.0	n/a	n/a	n/a	n/a	10.0	n/a	U
S131301240			7704-34-9	Sulfur	ug/mL	100	<5.00E-03	99%	n/a	n/a	n/a	n/a	10.0	n/a	
S13T301242			7732-10-2	Sulfuric	ug/mL	90.0	<0.00E-03	<10.0	n/a	n/a	n/a	n/a	10.0	n/a	U
S13T301240			7440-21-3	Tellurium	ug/mL	97%	<5.00E-03	1.13	n/a	n/a	n/a	n/a	10.0	n/a	
S13T301240			7440-24-0	Selenium	ug/mL	100	<2.00E-03	<4.00	n/a	n/a	n/a	n/a	4.00	n/a	U
S13T301240			7440-10-6	Titanium	ug/mL	97.6	<1.00E-03	<7.00	n/a	n/a	n/a	n/a	2.00	n/a	U
S131301240			7440-28-0	Thallium	ug/mL	91.3	<0.00E-03	<10.0	n/a	n/a	n/a	n/a	10.0	n/a	U
S13T301240			7440-58-6	Zinc	ug/mL	97%	<1.00E-03	<3.00	n/a	n/a	n/a	n/a	8.00	n/a	U
S131301240			7440-57-1	Zirconium	ug/mL	90.2	<1.00E-03	2.8%	n/a	n/a	n/a	n/a	2.00	n/a	U
OIL by TOC Titration															
S13T301242			HYDROXIDE	Hydroxide	ug/mL	88.8	<0.22	2.01E+01	n/a	n/a	n/a	n/a	1.11E+03	n/a	
TOC/TOC by Acid Persulfate															
S131301240			TIC	Total inorganic carbon	ug/mL	107	<7.00	7.72E+02	n/a	n/a	n/a	n/a	20.0	n/a	
S13T301242			TOC	Total organic carbon	ug/mL	80.7	<20.0	2.00E+03	n/a	n/a	n/a	n/a	200	n/a	
Parent Sample Number: S13T001217															
Sample#	R	Alt	Case	Analyte	Unit	STD %	Blank	Recall	Duplicate	Average	RPD %	Sys. Rec %	Det Limit	Cr. L. Br. %	Qual Flags
Arsenic and Small Organic Acids															

Table D-1. Tank 241-AW-106 BoilDown Chemical Analysis Results for all Submitted Liquid Samples (20 sheets)

AW106 BLDN 2013
Delta Summary Report

Sample Group: 20130422
Customer Group or SDG Number:
Segment Portion: Tank Composite (Supermarket Liquid)
Parent Sample Number: 513100124/

Sample	n	AW	CSG #	Analyte	Unit	STD %	Range	Result	Flag/Pass	As-type	RTN %	Spk Det %	Net Unit	CR Pct %	Qual Flag
Active and Final Organics															
513-007291				Hexane	ug/mL	20.2	<1.0E+03	792	OK	100	OK	100	24.2	100	
513-007291				Heptane	ug/mL	76.8	<0.1E+03	<10	OK	100	OK	100	14.1	OK U	
513-007291				Acetone	ug/mL	42.3	<6.0E+02	0.18	OK	100	OK	100	50.8	OK J	
513-007291				Formic	ug/mL	20.2	<1.0E+03	1.2E+03	OK	100	OK	100	70.0	OK U	
513-007291				Chloride	ug/mL	24.1	1.0E+03	3.17E+03	OK	100	OK	100	1.00	OK U	
513-007291				Nitrite	ug/mL	103	<0.1E+03	4.02E+04	OK	100	OK	100	2.90	OK	
513-007291				Bufole	ug/mL	25.5	<0.1E+03	3.41E+03	OK	100	OK	100	280	OK J	
513-007291				Carbon	ug/mL	76.8	<0.1E+03	<10	OK	100	OK	100	340	OK U	
513-007291				Stomach	ug/mL	24.1	<0.1E+03	<10	OK	100	OK	100	3.70	OK U	
513-007291				Nitrate	ug/mL	76.8	<0.1E+03	2.41E+04	OK	100	OK	100	3.15	OK	
513-007291				Phosphate	ug/mL	20.2	<0.1E+03	<10	OK	100	OK	100	250	OK U	
ULOV															
513-007291				Density	g/mL	00.42	0.4	1.307	OK	100	OK	100	1.000E 00	OK U	
ICP-RORANALYSIS															
513-007291				Aluminum	ug/mL	26.2	<0.1E+03	<10	OK	100	OK	100	12.0	OK	
513-007291				Asenite	ug/mL	103	<1.0E+03	<10	OK	100	OK	100	2.30	OK U	
513-007291				Barium	ug/mL	103	<1.0E+03	<10	OK	100	OK	100	2.30	OK U	
513-007291				Strontium	ug/mL	103	<1.0E+03	<10	OK	100	OK	100	2.30	OK U	
513-007291				Calcium	ug/mL	103	<1.0E+03	<10	OK	100	OK	100	2.30	OK U	
513-007291				Iron	ug/mL	103	<1.0E+03	<10	OK	100	OK	100	2.30	OK U	
513-007291				Vanadium	ug/mL	103	<1.0E+03	<10	OK	100	OK	100	2.30	OK U	
513-007291				Chromium	ug/mL	103	<1.0E+03	<10	OK	100	OK	100	2.30	OK U	
513-007291				Manganese	ug/mL	103	<1.0E+03	<10	OK	100	OK	100	2.30	OK U	
513-007291				Copper	ug/mL	103	<1.0E+03	<10	OK	100	OK	100	2.30	OK U	
513-007291				Zinc	ug/mL	103	<1.0E+03	<10	OK	100	OK	100	2.30	OK U	
513-007291				Selenium	ug/mL	103	<1.0E+03	<10	OK	100	OK	100	2.30	OK U	
513-007291				Antimony	ug/mL	103	<1.0E+03	<10	OK	100	OK	100	2.30	OK U	
513-007291				Lead	ug/mL	103	<1.0E+03	<10	OK	100	OK	100	2.30	OK U	
513-007291				Mercury	ug/mL	103	<1.0E+03	<10	OK	100	OK	100	2.30	OK U	
513-007291				Thallium	ug/mL	103	<1.0E+03	<10	OK	100	OK	100	2.30	OK U	
513-007291				Fluorine	ug/mL	103	<1.0E+03	<10	OK	100	OK	100	2.30	OK U	
513-007291				Bromine	ug/mL	103	<1.0E+03	<10	OK	100	OK	100	2.30	OK U	
513-007291				Iodine	ug/mL	103	<1.0E+03	<10	OK	100	OK	100	2.30	OK U	
513-007291				Sulfur	ug/mL	103	<1.0E+03	<10	OK	100	OK	100	2.30	OK U	
513-007291				Chlorine	ug/mL	103	<1.0E+03	<10	OK	100	OK	100	2.30	OK U	
513-007291				Nitrogen	ug/mL	103	<1.0E+03	<10	OK	100	OK	100	2.30	OK U	
513-007291				Oxygen	ug/mL	103	<1.0E+03	<10	OK	100	OK	100	2.30	OK U	
513-007291				Carbon	ug/mL	103	<1.0E+03	<10	OK	100	OK	100	2.30	OK U	
513-007291				Hydrogen	ug/mL	103	<1.0E+03	<10	OK	100	OK	100	2.30	OK U	
513-007291				Phosphorus	ug/mL	103	<1.0E+03	<10	OK	100	OK	100	2.30	OK U	

Table D-1. Tank 241-AW-106 Boildown Chemical Analysis Results for all Submitted Liquid Samples (20 sheets)

AW106 BLDN 2013
Data Summary Report

Sample Group: 20130122

Customer Group or SDG Number:

Segment Portion: Tank Composite (Supernatant Liquid)

Parent Sample Number: 513T001247

Sample#	R	AW	C/S#	Analyte	Unit	STD %	Blank	Result	Duplicate	Average	RPD %	Spk Rec %	Det Limit	Cor Det %	Qual Flags
ICP RCRA Metals															
513T001251			7440-23-6	Endium	ug/ml	98.0	<0.14-30	1.09E-10	n/a	n/a	n/a	n/a	10.0	n/a	
513T001251			7440-07-0	Nickel	ug/mL	100	<1.00E-09	30.0	n/a	n/a	n/a	n/a	2.00	n/a	
513T001251			7723-14-0	Phosphorus	ug/ml	66.1	<3.00E-09	3.44	n/a	n/a	n/a	n/a	6.00	n/a	
513T001251			7440-10-1	Lead	ug/mL	104	<5.00E-09	12.0	n/a	n/a	n/a	n/a	12.0	n/a	
513T001251			7194-24-9	Sulfur	ug/mL	100	<5.00E-09	1.29E-10	n/a	n/a	n/a	n/a	10.0	n/a	
513T001251			7782-10-2	Selenium	ug/mL	98.0	<5.00E-09	<12.0	n/a	n/a	n/a	n/a	12.0	n/a	U
513T001251			7440-21-3	Silver	ug/ml	97.0	<5.00E-09	30.0	n/a	n/a	n/a	n/a	10.0	n/a	U
513T001251			7440-24-0	Silverium	ug/mL	100	<2.00E-09	<4.00	n/a	n/a	n/a	n/a	4.00	n/a	U
513T001251			7440-30-6	Titanium	ug/ml	67.8	<1.00E-09	<3.00	n/a	n/a	n/a	n/a	3.00	n/a	U
513T001251			7440-29-0	Thallium	ug/mL	91.3	<5.00E-09	<12.0	n/a	n/a	n/a	n/a	12.0	n/a	U
513T001251			7440-00-0	Zinc	ug/mL	100	<1.00E-09	<3.00	n/a	n/a	n/a	n/a	3.00	n/a	U
513T001251			7440-50-7	Zinczincum	ug/ml	90.2	<5.00E-09	<3.00	n/a	n/a	n/a	n/a	3.00	n/a	U
OH by Pot Titration															
513T001251			HYDROXIDE	Hydroxide	ug/mL	88.8	<9.00	2.07E+04	n/a	n/a	n/a	n/a	1.11E+03	n/a	
ICP TOC by Acid Persulfate															
513T001251			TC	Total Inorganic carbon	ug/mL	101	<7.00	1.02E+01	n/a	n/a	n/a	n/a	70.0	n/a	
513T001251			OC	total organic carbon	ug/ml	89.1	<0.00	1.40E-10	n/a	n/a	n/a	n/a	200	n/a	

Parent Sample Number: 513T001248

Sample#	R	AW	C/S#	Analyte	Unit	STD %	Blank	Result	Duplicate	Average	RPD %	Spk Rec %	Det Limit	Cor Det %	Qual Flags
Alcohols and Small Organic Acids															
513T001250			16004-40-1	Fluoride	ug/ml	95.2	<0.00E-09	1.09E-10	n/a	n/a	n/a	n/a	24.2	n/a	
513T001250			898-14-6	Glycolic acid	ug/mL	94.8	<9.97E-09	0.00	n/a	n/a	n/a	n/a	141	n/a	U
513T001250			71-50-1	Acetic acid	ug/ml	62.6	<5.00E-09	0.00	n/a	n/a	n/a	n/a	60.6	n/a	U
513T001250			123-11-07-5	Formate	ug/mL	98.9	<4.80E-09	1.29E-10	n/a	n/a	n/a	n/a	10.0	n/a	U
513T001250			16007-40-5	Chloride	ug/mL	60.1	0.0110	2.11E+08	n/a	n/a	n/a	n/a	100	n/a	
513T001250			14702-00-3	Nitrate	ug/ml	97.0	<0.0110	5.23E+04	n/a	n/a	n/a	n/a	200	n/a	
513T001250			14006-79-1	Sulfate	ug/mL	90.3	<0.0110	5.00E+05	n/a	n/a	n/a	n/a	200	n/a	

Table D-1. Tank 241-AW-106 Boildown Chemical Analysis Results for all Submitted Liquid Samples (20 sheets)

AW106 BI DN 2013
Data Summary Report

Sample Group: 20130122

Customer Group or SDG Number:

Segment Portion: Tank Composite (Supernatant Liquid)

Parent Sample Number: 5131001248

Sample#	R	AW	CASE	Analyte	Unit	STD %	Blank	Result	Duplicate	Average	LOD %	Spk Rec %	Det Limit	Cre Lim %	Qual Flag
Anions and Total Organic Acids															
518T301252			0011-01-5	Oxalate	ug/L	90.0	<0.0231	<540	n/a	n/a	n/a	n/a	340	n/a	L
513T301252			21006-07-3	Formate	ug/ml	86.0	<0.0500	<870	n/a	n/a	n/a	n/a	870	n/a	L
5131301252			14787-55-3	Nitrate	ug/L	94.4	<0.0228	1.57E+01	n/a	n/a	n/a	n/a	312	n/a	
518T301252			14205-44-2	Phosphate	ug/ml	66.6	<0.0187	<180	n/a	n/a	n/a	n/a	250	n/a	L
DENSITY															
513T301252				Density	g/ml	86.42	n/a	1.317	n/a	n/a	n/a	n/a	0.0001	n/a	
ED-45031A Metals															
518T301252			7410-00-6	Aluminum	ug/L	60.0	<0.00E+00	8.00E+00	n/a	n/a	n/a	n/a	12.0	n/a	
513T301252			7440-76-2	Arsenic	ug/ml	86.2	<5.00E-03	<1.00	n/a	n/a	n/a	n/a	10.0	n/a	L
518T301252			7410-30-8	Barium	ug/L	901	<0.00E+00	<2.00	n/a	n/a	n/a	n/a	2.00	n/a	L
513T301252			7440-41-7	Beryllium	ug/ml	870	<1.00E-03	<1.00	n/a	n/a	n/a	n/a	2.00	n/a	L
5131301252			7440-70-2	Calcium	ug/L	95.5	<0.00E+00	<1.00	n/a	n/a	n/a	n/a	100	n/a	L
513T301252			7440-43-8	Cadmium	ug/ml	87.0	<1.00E-03	<1.00	n/a	n/a	n/a	n/a	2.00	n/a	L
5131301252			7440-47-3	Chromium	ug/L	901	<0.00E+00	0.00	n/a	n/a	n/a	n/a	2.00	n/a	
518T301252			7410-53-1	Fluorine	ug/ml	870	<1.00E-03	<1.00	n/a	n/a	n/a	n/a	2.00	n/a	L
5131301252			7439-99-0	Iron	ug/L	903	<0.01E+00	34.9	n/a	n/a	n/a	n/a	20.0	n/a	L
518T301252			7410-00-7	Potassium	ug/ml	66.7	<0.00E+00	8.00E+00	n/a	n/a	n/a	n/a	10.0	n/a	
5131301252			7439-97-0	Lanthanum	ug/L	904	<0.00E+00	<2.00	n/a	n/a	n/a	n/a	2.00	n/a	L
518T301252			7439-95-2	Lithium	ug/ml	876	<1.00E-03	<1.00	n/a	n/a	n/a	n/a	2.00	n/a	L
5131301252			7410-08-7	Molybdenum	ug/L	98.0	<0.00E+00	32.2	n/a	n/a	n/a	n/a	2.00	n/a	
518T301252			7440-20-5	Sodium	ug/L	60.0	<0.01E+00	1.00E+00	n/a	n/a	n/a	n/a	80.0	n/a	
5131301252			7410-00-6	Nickel	ug/L	900	<0.00E+00	27.5	n/a	n/a	n/a	n/a	2.00	n/a	
518T301252			7723-14-0	Phosphorus	ug/L	60.1	<0.00E+00	870	n/a	n/a	n/a	n/a	0.00	n/a	
513T301252			7430-02-1	Tand	ug/ml	874	<5.00E-03	<1.00	n/a	n/a	n/a	n/a	10.0	n/a	L
5131301252			7704-24-9	Sulfur	ug/L	900	<0.00E+00	1.49E+02	n/a	n/a	n/a	n/a	10.0	n/a	
518T301252			7782-10-2	Sulfuric	ug/L	60.0	<0.00E+00	<1.00	n/a	n/a	n/a	n/a	12.0	n/a	L
5131301252			7440-21-3	Tin	ug/ml	900	<5.00E-03	64.9	n/a	n/a	n/a	n/a	10.0	n/a	L

Table D-1. Tank 241-AW-106 Boildown Chemical Analysis Results for all Submitted Liquid Samples (20 sheets)

AW106 BLUN 2013
Delta Summary Report

Sample Group: 20130122
Customer Group or SFG Number:
Segment Portion: Tank Composites (Supernatant Liquid)
Parent Sample Number: S13T001248

Sample	ID	Case #	Analyte	Unit	STD %	Blank	Result	Duplicate	Average	BLN %	Spk Rec %	Det Limit	Chr Len	Qual Flag
ICP-AES Analysis														
S13-037292		7440-21-6	Uranium	ug/mL	100	<1.30E-03	44.03	n/a	n/a	n/a	n/a	4.30	n/a	n/a
S13-037292		7440-57-6	Thallium	ug/mL	97.5	<1.30E-03	<2.00	n/a	n/a	n/a	n/a	2.30	n/a	n/a
S13-037292		7440-25-0	Thallium	ug/mL	97.5	<1.30E-03	<1.70	n/a	n/a	n/a	n/a	13.0	n/a	n/a
S13-037292		7440-49-6	Lead	ug/mL	100	<1.30E-03	<0.03	n/a	n/a	n/a	n/a	0.30	n/a	n/a
S13-037292		7440-47-7	Chromium	ug/mL	98.2	<1.30E-03	2.13	n/a	n/a	n/a	n/a	2.30	n/a	n/a
ICP-MS Analysis														
S13-037292		7440-49-6	Lead	ug/mL	98.2	<1.30E-03	1.70E+01	n/a	n/a	n/a	n/a	1.1E+03	n/a	n/a
TOC/DOC by Nal Persulfate														
S13-037292		7440-49-6	Total Inorganic Carbon	ug/mL	98.2	<1.30E-03	67.63	n/a	n/a	n/a	n/a	70.0	n/a	n/a
S13-037292		7440-49-6	Total Organic Carbon	ug/mL	98.2	<1.30E-03	1.22E+03	n/a	n/a	n/a	n/a	230	n/a	n/a
Parent Sample Number: S13T001248														
Sample	ID	Case #	Analyte	Unit	STD %	Blank	Result	Duplicate	Average	BLN %	Spk Rec %	Det Limit	Chr Len	Qual Flag
Aromatic and Total Organic Acids														
S13-037292		7440-49-6	Fluoride	ug/mL	95.4	<1.30E-03	1.01E+03	n/a	n/a	n/a	n/a	24.0	n/a	n/a
S13-037292		7440-49-6	Sulfate	ug/mL	95.4	<1.30E-03	<1.11	n/a	n/a	n/a	n/a	1.1	n/a	n/a
S13-037292		7440-49-6	Acetate	ug/mL	95.4	<1.30E-03	6.15	n/a	n/a	n/a	n/a	5.1E	n/a	n/a
S13-037292		7440-49-6	Formate	ug/mL	95.4	<1.30E-03	1.00E+03	n/a	n/a	n/a	n/a	70.0	n/a	n/a
S13-037292		7440-49-6	Phosphate	ug/mL	95.4	<1.30E-03	2.42E+03	n/a	n/a	n/a	n/a	190	n/a	n/a
S13-037292		7440-49-6	Nitrate	ug/mL	100	<1.30E-03	5.01E+04	n/a	n/a	n/a	n/a	230	n/a	n/a
S13-037292		7440-49-6	Bicarbonate	ug/mL	95.4	<1.30E-03	7.15E+03	n/a	n/a	n/a	n/a	230	n/a	n/a
S13-037292		7440-49-6	Chloride	ug/mL	95.4	<1.30E-03	6.15	n/a	n/a	n/a	n/a	340	n/a	n/a
S13-037292		7440-49-6	Bromide	ug/mL	95.4	<1.30E-03	5.15	n/a	n/a	n/a	n/a	8.70	n/a	n/a
S13-037292		7440-49-6	Sulfate	ug/mL	95.4	<1.30E-03	1.75E+03	n/a	n/a	n/a	n/a	310	n/a	n/a
S13-037292		7440-49-6	Phosphate	ug/mL	95.4	<1.30E-03	1.74E+03	n/a	n/a	n/a	n/a	740	n/a	n/a
Density														
S13-037292		7440-49-6	Density	g/mL	95.4	<1.30E-03	1.01	n/a	n/a	n/a	n/a	1.0E-100	n/a	n/a

Table D-1. Tank 241-AW-106 Boildown Chemical Analysis Results for all Submitted Liquid Samples (20 sheets)

AW106 BLDN 2013
Data Summary Report

Sample Group: 20130122

Customer Group or SDG Number:

Segment Portion: Tank Composite (Supernatant Liquid)

Parent Sample Number: S131001249

Sample#	ID	Alt	C&S#	Analyte	Unit	STD %	Mask	Result	Duplicate	Average	RPD %	Spk Rec %	Det Limit	Corr Det %	Qual Flags
ICP-RFCA Mask															
S131301250	7430-09-8			Aluminum	ug/mL	95.5	<5.0E-03	6.00E+02	n/a	n/a	n/a	n/a	12.0	n/a	
S18T301250	7440-20-2			Antimony	ug/mL	60.2	<5.0E-03	<10.0	n/a	n/a	n/a	n/a	16.0	n/a	U
S13T301250	7440-30-8			Barium	ug/mL	87.1	<1.0E-03	<7.00	n/a	n/a	n/a	n/a	2.00	n/a	U
S131301250	7440-41-7			Beryllium	ug/mL	102	<1.0E-03	<2.00	n/a	n/a	n/a	n/a	2.00	n/a	U
S131301250	7440-70-2			Calcium	ug/mL	66.6	<0.0000	<1.00	n/a	n/a	n/a	n/a	100	n/a	U
S13T301250	7440-13-0			Cadmium	ug/mL	91.0	<1.0E-03	3.11	n/a	n/a	n/a	n/a	2.00	n/a	J
S131301250	7440-47-3			Chromium	ug/mL	101	<1.0E-03	5.01	n/a	n/a	n/a	n/a	2.00	n/a	
S18T301250	7440-08-1			Europium	ug/mL	100	<1.0E-03	<2.00	n/a	n/a	n/a	n/a	2.00	n/a	U
S13T301250	7439-98-6			Iron	ug/mL	873	<0.0100	53.7	n/a	n/a	n/a	n/a	20.0	n/a	I
S131301250	7440-09-7			Kryptonium	ug/mL	98.7	<0.0000	5.07E+03	n/a	n/a	n/a	n/a	40.0	n/a	
S13T301250	7430-01-0			Lanthanum	ug/mL	87.1	<1.0E-03	<7.00	n/a	n/a	n/a	n/a	2.00	n/a	U
S131301250	7439-92-2			Lithium	ug/mL	105	<1.0E-03	<2.00	n/a	n/a	n/a	n/a	2.00	n/a	U
S18T301250	7430-08-7			Molybdenum	ug/mL	60.0	<1.0E-03	27.8	n/a	n/a	n/a	n/a	2.00	n/a	
S13T301250	7440-20-8			Sodium	ug/mL	86.0	<0.0000	1.45E+04	n/a	n/a	n/a	n/a	60.0	n/a	
S131301250	7440-02-0			Nickel	ug/mL	100	<1.0E-03	23.7	n/a	n/a	n/a	n/a	2.00	n/a	
S13T301250	7732-18-0			Phosphorus	ug/mL	66.1	<3.0E-03	<8.0	n/a	n/a	n/a	n/a	6.00	n/a	
S131301250	7439-92-1			Lead	ug/mL	104	<5.0E-03	<12.0	n/a	n/a	n/a	n/a	12.0	n/a	U
S18T301250	7704-34-0			Sulfur	ug/mL	100	<5.0E-03	2.00E+03	n/a	n/a	n/a	n/a	16.0	n/a	
S13T301250	7702-49-2			Tellurium	ug/mL	86.0	<5.0E-03	<12.0	n/a	n/a	n/a	n/a	12.0	n/a	U
S131301250	7440-27-3			Silver	ug/mL	103	<5.0E-03	30.7	n/a	n/a	n/a	n/a	16.0	n/a	J
S13T301250	7440-26-6			Selenium	ug/mL	87.0	<3.0E-03	<1.00	n/a	n/a	n/a	n/a	6.00	n/a	U
S131301250	7440-22-8			Titanium	ug/mL	91.8	<1.0E-03	<2.00	n/a	n/a	n/a	n/a	2.00	n/a	U
S18T301250	7440-28-0			Thallium	ug/mL	67.8	<5.0E-03	<12.0	n/a	n/a	n/a	n/a	16.0	n/a	U
S13T301250	7440-00-0			Zinc	ug/mL	87.0	<4.0E-03	<3.00	n/a	n/a	n/a	n/a	6.00	n/a	U
S131301250	7440-57-7			Zirconium	ug/mL	98.2	<1.0E-03	2.04	n/a	n/a	n/a	n/a	2.00	n/a	J
OH- by Vol. Titration															
S131301250	HYDROXIDE			Hydroxide	ug/mL	86.8	<0.00	1.00E+04	n/a	n/a	n/a	n/a	1.01E+03	n/a	
ICP-TOC by Acid Persulfate															

Table D-1. Tank 241-AW-106 Boildown Chemical Analysis Results for all Submitted Liquid Samples (20 sheets)

AW106 RI DN 2013
Data Summary Report

Sample Group: 20130122

Customer Group or SDG Number:

Segment Portion: Tank Composite (Supernatant Liquid)

Parent Sample Number: 513T001249

Sample	R	#	QAS #	Analyte	Unit	STD %	Blank	Result	Duplicate	Average	RPD %	Spk Rec %	Det Limit	Cer Rec %	Qual Flag
513T001253			TC	Total inorganic carbon	ug/ml	99.0	<7.00	7.37E+02	n/a	n/a	n/a	n/a	70.0	n/a	
513T001258			OC	Total organic carbon	ug/mL	99.7	<20.0	1.44E+03	n/a	n/a	n/a	n/a	200	n/a	
Total Carbon by Furnace															
513T001253			TC	Total carbon	ug/ml	100	10.5	9.81E+02	n/a	n/a	n/a	n/a	400	n/a	

LAB-RPT-13-00003 R0
Attachment D

ATTACHMENT E

SOLID PHASE CHARACTERIZATION OF BOILDOWN SOLIDS

Solid Phase Characterization Results for the Tank 241-AW-106 Boildown Samples

Four samples were received on 3/11/2013 for solid phase characterization (SPC) from the tank 241-AW-106 boildown experiment performed at the 222-S Laboratory. The 4 samples were labeled with the following OmniLIMS numbers with the corresponding concentration or dilution step in parentheses, S13T001244 (Con-5), S13T001245 (Con-6), S13T001246 (Con-7), and S13T001254 (Dil-3). All samples were in the form of wet, fine-grained, white solids contained in 25-mL glass vials with a residual supernatant liquid (clear, yellow) on top of the solids.

The samples were prepared for scanning electron microscopy (SEM) analysis using the residual supernatant liquid to help disperse the particulate. This was accomplished by placing a 37-mm diameter cellulose backing pad and a 0.45-micron pore size, Nucleopore polycarbonate filter on the fritted glass base of a filtration flask connected to a trap and house vacuum. A filtration funnel was then placed on the filter stack and clamped into place. For each sample, a pipette was inserted in the sample vial and used to stir the slurry of particulate and supernatant liquid. A small portion of the solids was then transferred, via pipette, to the filtration stand and was streaked onto the filter surface. The vacuum apparatus was then quickly and gently shaken to help disperse the solids across the filter surface, and the vacuum was immediately turned on. When the fluid had drained from the filter surface, the clamp and funnel were removed, and the filter was allowed to completely dry. A section of the filter was cut out and, using carbon paint, affixed to an aluminum SEM stub containing a carbon planchet. The resulting SEM specimens were then coated with a conductive coating of carbon by evaporative deposition.

SEM analysis was conducted using an Aspex®⁵ Personal Scanning Electron Microscope (PSEM), Model II, with a Noran light element energy dispersive spectrometer (EDS) for chemical analysis using procedure ATS-LT-161-100, *222-S Laboratory Sample Preparation and Operating Procedure for Scanning Electron Microscopes*, and recorded in the controlled laboratory notebook, HNF-N-832-1, "PSEM Instrument Notebook," page 182. The instrument was operated at an accelerating voltage of 20 kV, and the samples were mounted at a working distance of 20 mm. All images were acquired in secondary electron image (SEI) mode. EDS spectra were acquired for 30 seconds live time (unless noted) on relatively smooth surfaces (either flat or sloping toward the detector) near the center of the image.

For polarized light microscopy (PLM) analysis, all four samples had sufficient liquid to be mounted in the original liquor. For a full description of the individual images, see the controlled laboratory notebook HNF-N-395-1, "Polarized Light Microscopy Sample Log," pages 116-117.

The samples were prepared for X-ray diffraction (XRD) analysis by placing a fraction on a filter paper to remove interstitial liquid, which was transferred to the well of a quartz zero-background slide, compressed with the plane of a glass slide, fixed with collodion binder, and allowed to dry. XRD analysis was performed on March 11-13, 2012 in accordance with ATS-LT-507-103, Revision B-0, "222-S Laboratory X-Ray Diffractometry (XRD) Using the Rigaku MiniFlex II." Refer to laboratory notebook HNF-N-710-1, "Rigaku®⁶ MiniFlex II X-Ray Diffractometer (XRD) Maintenance and Operations," page 22, for test information and specifics. The sample compositions reported below are relative amounts based upon all the crystalline species present in each individual sample. Nitratine and sodium nitrite are speculated to have crystallized from the interstitial liquid when the samples were dried during sample preparation.

⁵ Aspex® is a registered trademark of Aspex Corporation, Delmont, Pennsylvania.

⁶ Rigaku® is a registered trademark of Rigaku/USA, Inc., Danvers, Massachusetts.

S13T001244

Analysis by PLM detected three main phases: natrophosphate (bipyramidal isotropic phase), kogarkoite (flat, hexagonal or shards thereof, anisotropic), and sodium carbonate (mostly needle form with some small laths). The image on the left in Figure E-1 is an overview, while the image on the right focuses on the cluster of needles. In both cases, the crossed polarizers (crP+) were in place.

Figure E-1. Polarized Light Microscopy Analysis of Sample S13T001244.

(S13T001244, 20x, crP+, Red I compensator)

(S13T001244, 60x, crP+, Red I compensator)

Analysis by XRD observed the sample to consist of a minimal amount of homogeneous yellowish-white fine solids in a light yellowish liquid, and once dried appeared to be homogeneous light yellowish-white fine solids. Five different phases in the sample were identified; these are listed in Table E-1 and identified on the spectrum in Figure E-2.

Table E-1. Phases and Relative Amounts Identified in Sample S13T001244.

Chemical Name	Mineral Name	Formula	~Rel. Amount
Sodium Fluoride Sulfate	Kogarkoite	$\text{Na}_3\text{SO}_4\text{F}$	Minor
Sodium Fluoride Phosphate Hydrate	Natrophosphate	$\text{Na}_7\text{F}(\text{PO}_4)_2 \cdot 19\text{H}_2\text{O}$	Major
Sodium Nitrate	Nitratine	NaNO_3	Major
Sodium Nitrite	--	NaNO_2	Minor
Sodium Carbonate Monohydrate	Thermonatrite	$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$	Major

Figure E-2. X-Ray Diffraction Spectrum from Sample S13T001244.

The SEM analysis identified three main phases present in the sample. They consisted of larger, octahedral crystals of sodium fluoride phosphate identified as natrophosphate, Figure E-3b; aggregates and smaller crystals of sodium fluoride sulfate, Figure E-3c; and small, acicular crystals rich in sodium, carbon, and oxygen, Figure E-4.

Figure E-3. Scanning Electron Microscopy Images and Energy Dispersive Spectrometry Spectra of Two Phases in Sample S13T001244.

Figure E-4. Scanning Electron Microscopy Image and Energy Dispersive Spectrometry Spectrum of Acicular Particles in Sample S13T001244.

S13T001245

Analysis by PLM showed that sodium carbonate was the dominant phase, followed by clusters of kogarkoite (greenish color, confirmed with SEM images), sodium oxalate needles, and natrophosphate crystals, Figure E-5. One crystal of sodium nitrate was found.

Figure E-5. Polarized Light Microscopy Analysis of Sample S13T001245.

(S13T001245, 10x, crP+, Red I compensator)

(S13T001245, 10x, uncrP)

Analysis by XRD identified the major phase as nitratine $[\text{NaNO}_3]$. Kogarkoite $[\text{Na}_3\text{SO}_4\text{F}]$, natrophosphate $[\text{Na}_7\text{F}(\text{PO}_4)_2 \cdot 19\text{H}_2\text{O}]$, sodium nitrite $[\text{NaNO}_2]$, and thermonatrite $[\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}]$ were identified as minor phases. The results are tabulated in Table E-2, and the XRD spectrum is shown in Figure E-6.

Table E-2. Phases and Relative Amounts Identified in Sample S13T001245.

Chemical Name	Mineral Name	Formula	~Rel. Amount
Sodium Fluoride Sulfate	Kogarkoite	$\text{Na}_3\text{SO}_4\text{F}$	Minor
Sodium Fluoride Phosphate Hydrate	Natrophosphate	$\text{Na}_7\text{F}(\text{PO}_4)_2 \cdot 19\text{H}_2\text{O}$	Minor
Sodium Nitrate	Nitratine	NaNO_3	Major
Sodium Nitrite	--	NaNO_2	Minor
Sodium Carbonate Monohydrate	Thermonatrite	$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$	Minor

Figure E-6. X-Ray Diffraction Spectrum from Sample S13T001245.

Analysis of the sample by SEM showed three major phases. The zoomed-in image on the right in Figure E-7 shows all three phases; Spot 1 is a sodium fluoride phosphate (natrophosphate), Spot 2 is a sodium fluoride sulfate, and Spot 3 is a sodium and carbon-rich phase which is possibly sodium carbonate.

Another sodium- and carbon-rich phase is shown in Figure E-8 which also has trace aluminum, sulfur, and potassium. In addition, a trace amount of sodium nitrate was observed as evidenced in Figure E-9.

Figure E-7. Scanning Electron Microscopy Images and Energy Dispersive Spectroscopy Spectra of Three Phases in Sample S13T001245.

Figure E-8. Scanning Electron Microscopy Image and Energy Dispersive Spectroscopy Spectrum of Thread-Like Particles in Sample S13T001245.

Figure E-9. Scanning Electron Microscopy Image and Energy Dispersive Spectroscopy Spectrum of a Sodium Nitrate Particle in Sample S13T001245.

S13T001246

Analysis by PLM showed few changes in appearance compared to Sample S13T001245; kogarkoite is reduced, carbonate is dominant, sodium oxalate needles are present, and natrophosphate is rare (Figure E-10). One sodium nitrate crystal was also observed, Figure E-11.

Figure E-10. Polarized Light Microscopy Analysis of Sample S13T001246.

(S13T001246, 20x, crP+, Red I compensator)

(S13T001246, 20x, uncrP)

Figure E-11. Polarized Light Microscopy Analysis of Sample S13T001246 Showing a Sodium Nitrate Crystal.

(S13T001246, 20x, crP+, Red I compensator)

Analysis by XRD identified major phases as nitratine [NaNO₃] and thermonatrite [Na₂CO₃•H₂O]. Kogarkoite [Na₃SO₄F], natrophosphate [Na₇F(PO₄)₂•19H₂O], and sodium nitrite [NaNO₂] were identified as minor phases. The results are tabulated in Table E-3, and the XRD spectrum is shown in Figure E-12.

Table E-3. Phases and Relative Amounts Identified in Sample S13T001246.

Chemical Name	Mineral Name	Formula	~Rel. Amount
Sodium Fluoride Sulfate	Kogarkoite	Na ₃ SO ₄ F	Minor
Sodium Fluoride Phosphate Hydrate	Natrophosphate	Na ₇ F(PO ₄) ₂ •19H ₂ O	Minor
Sodium Nitrate	Nitratine	NaNO ₃	Major
Sodium Nitrite	--	NaNO ₂	Minor
Sodium Carbonate Monohydrate	Thermonatrite	Na ₂ CO ₃ •H ₂ O	Major

Figure E-12. X-Ray Diffraction Spectrum from Sample S13T001246.

Analysis by SEM observed three major phases. The sample was dominated by larger, blade-like crystals which were chemically and morphologically consistent with sodium carbonate, Figure E-13. Sodium fluoride phosphate and sodium fluoride sulfate were also identified and were of similar morphology as the same phases seen in Samples S13T001244 and S13T001245, Figures E-14 and E-15.

Figure E-13. Scanning Electron Microscopy Image and Energy Dispersive Spectroscopy Spectrum of a Possible Sodium Carbonate Particle in Sample S13T001246.

Figure E-14. Scanning Electron Microscopy Image and Energy Dispersive Spectroscopy Spectrum of Natrophosphate in Sample S13T001246.

Figure E-15. Scanning Electron Microscopy Image and Energy Dispersive Spectroscopy Spectrum of Sodium Fluoride Sulfate in Sample S13T001246.

S13T001254

Analysis by PLM showed three main phases; natrophosphate (isotropic), kogarkoite (irregular anisotropic), and oxalate needles, Figure E-16. Right image is a close-up on natrophosphate and oxalate needles. One crystal of carbonate was found in two preparation slides.

Figure E-16. Polarized Light Microscopy Analysis of Sample S13T001254.

(S13T001254, 10x, crP+, Red I compensator)

(S13T001254, 40x, uncrP)

Analysis by XRD showed that the major phases of the sample were natroxalate $[\text{Na}_2\text{C}_2\text{O}_4]$, nitratine $[\text{NaNO}_3]$, and thermonatrite $[\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}]$. Natrophosphate $[\text{Na}_7\text{F}(\text{PO}_4)_2 \cdot 19\text{H}_2\text{O}]$ and sodium nitrite $[\text{NaNO}_2]$ were identified as minor phases. The results are tabulated in Table E-4, and the XRD spectrum is shown in Figure E-17.

Table E-4. Phases and Relative Amounts Identified in Sample S13T001254.

Chemical Name	Mineral Name	Formula	~Rel. Amount
Sodium Fluoride Phosphate Hydrate	Natrophosphate	$\text{Na}_7\text{F}(\text{PO}_4)_2 \cdot 19\text{H}_2\text{O}$	Minor
Sodium Oxalate	Natroxalate	$\text{Na}_2\text{C}_2\text{O}_4$	Major
Sodium Nitrate	Nitratine	NaNO_3	Major
Sodium Nitrite	--	NaNO_2	Minor
Sodium Carbonate Monohydrate	Thermonatrite	$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$	Major

Figure E-17. X-Ray Diffraction Spectrum from Sample S13T001254.

Analysis by SEM showed that the sample consisted mainly of small acicular particles rich in sodium, carbon, and oxygen, Figure E-18. Interspersed were larger crystals of natrophosphate, Figure E-19. A more magnified image of the acicular crystals showed the morphology of uniformly flat with rounded edges suggesting sodium oxalate, Figure E-20.

Figure E-18. Scanning Electron Microscopy Images and Energy Dispersive Spectroscopy Spectrum of the Major Particulate in Sample S13T001254.

Figure E-19. Scanning Electron Microscopy Image and Energy Dispersive Spectroscopy Spectrum of Natrophosphate in Sample S13T001254.

Figure E-20. Scanning Electron Microscopy Image and Energy Dispersive Spectroscopy Spectrum of Sodium Oxalate in Sample S13T001254.

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