

**2018 ANNUAL GROUNDWATER  
MONITORING AND CORRECTIVE  
ACTION REPORT  
FEDERAL CCR RULE**

**BRANDYWINE ASH MANAGEMENT FACILITY  
PHASE II, BRANDYWINE, MARYLAND**

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## 1. INTRODUCTION

The Federal Coal Combustion Residuals (CCR) Rule (40 Code of Federal Regulations [CFR] Part 257.90(e)) (USEPA, 2015) requires owners and or operators of existing CCR landfills to prepare a Groundwater Monitoring and Corrective Action Report (Report) no later than 31 January 2019. Geosyntec Consultants (Geosyntec) has prepared this Report for Phase II at the Brandywine Ash Management Facility in Brandywine, Maryland (Site). This Report summarizes the groundwater monitoring activities conducted pursuant to the CCR Rule through December 31, 2018.

## 2. SITE DESCRIPTION

### 2.1 Site Description

The Site is located in Brandywine, Prince George's County, Maryland (**Figure 1**) and is operated by GenOn MD Ash Management LLC (MD Ash). The Site is a dry ash management operation and does not have CCR surface impoundments (SI) as defined in the CCR Rule. The Site encompasses 217 acres of which approximately 29 acres have been used to manage CCR at the Phase II cell. Phase I, Historical Area 1, and Historical Area 2 are located adjacent to Phase II, are inactive, and therefore are not regulated by the Federal CCR Rule. Phase II was constructed with a geosynthetic bottom liner and associated leachate collection system that directs leachate to Pond 006, located directly to the east. Non-contact storm water runoff is directed away from Phase II through perimeter ditches. In addition to leachate, Pond 006 is used to manage contact storm water. Pond 006 is exempt from the Federal CCR Rule. Features of the Site and their locations are presented on **Figure 2**.

### 2.2 Regional Physiographic Setting

The Site is located on the Atlantic Coastal Plain province of Maryland and was previously used for sand and gravel mining operations. The sand and gravel unit is the upper aquifer at the Site as defined in the CCR Rule. A regional aquitard (the Calvert Formation) underlies the sand and gravel.

Regional groundwater flow in the upper aquifer in the site vicinity is to the north/northeast toward the Mataponi Creek which is incised into the Calvert Formation confining unit that is considered to be the discharge location for shallow groundwater above the Calvert Formation confining unit. Groundwater flow directions are locally variable and are influenced by nearby tributaries to Mataponi Creek that are localized groundwater discharge zones.

## 3. GROUNDWATER MONITORING SYSTEM

This section describes the groundwater monitoring well network for the CCR Rule at Phase II. This network utilizes some monitoring wells initially installed as part of a separate site-wide hydrogeologic investigation as well as additional wells installed explicitly for the CCR Rule. As described in the *Basis for Groundwater Monitoring Network* (Geosyntec, 2017a), the groundwater

monitoring network around Phase II was designed to comply with 40 CFR 257.91. No monitoring wells were installed or decommissioned during 2018.

Groundwater quality is monitored around Phase II through a network of eleven monitoring wells. As shown on **Figure 3**, there are seven compliance monitoring wells (B15S, B16, B26, B27, B37, B38, and B39) and four background monitoring wells (B34, B35, B36, and B41). These background locations were selected in consultation with Maryland Department of Environment (MDE) under a separate regulatory program. Monitoring well construction and soil boring logs were provided in *Basis for Groundwater Monitoring Network* (Geosyntec, 2017a). Compliance and background monitoring well construction details are summarized in **Table 1**.

## **4. CCR RULE GROUNDWATER KEY ACTIVITIES COMPLETED – 2018**

### **4.1 Groundwater Monitoring**

The baseline monitoring program was completed in August 2017 and the Site transitioned to detection monitoring beginning in October 2017. Groundwater monitoring continued in 2018 and was conducted in accordance with the *Sampling and Analysis Plan* (SAP) provided in Geosyntec (2015). Detection monitoring is performed on a semi-annual basis.

#### *4.1.1 Detection Monitoring Program*

**Table 2** summarizes the history of baseline and detection monitoring events through 2018. Sampling occurred in April /May and July/August of 2018. In accordance with 40 CFR 257.94(a) of the CCR Rule, samples were analyzed for Appendix III list constituents only. Prior to sampling, a synoptic round of groundwater measurements was collected from the compliance and background monitoring wells. Groundwater elevation data are presented in **Table 3**. Analytical results are summarized in **Table 4** and **Table 5**. The Site remains in detection monitoring.

#### *4.1.2 Groundwater Elevation and Flow Velocities*

Groundwater elevation monitoring was conducted in April and July 2018. A synoptic round of water level measurements was made at the start of each monitoring event. Groundwater elevation measurements were collected in accordance with the SAP. Potentiometric surface maps based on the elevations measured during the April/May and July/August 2018 monitoring events are presented on **Figure 4** and **Figure 5**, respectively. Because only CCR Rule monitoring wells were gauged for the April/May 2018 event, **Figure 4** presents the potentiometric surface surrounding Phase II and background locations only. The potentiometric surface from January 2018, collected under a separate regulatory program, is provided on **Figure 6**. Groundwater elevation data are summarized in **Table 3**. As shown by **Figures 4, 5, and 6** groundwater under the eastern half of Phase II flows from west to east. The groundwater elevations and flow directions are very stable among the various monitoring events.

As shown in **Appendix A** and on **Figure 5** and **Figure 6**, the average hydraulic gradient around Phase II ranged from 0.0252 ft/ft between monitoring wells B16 and B28 to 0.0075 ft/ft between monitoring wells B16 and B27. **Table A-2** shows groundwater flow velocities at the Site ranged from  $1.39 \times 10^{-4}$  centimeters per second (cm/sec) (144 inches/month; 144 feet/year) between monitoring wells B16 and B28 to  $4.13 \times 10^{-6}$  cm/sec (4.27 inches/month; 4.27 feet/year) between monitoring wells B26 and B27.

#### **4.2 Data Usability**

Upon receipt of laboratory analytical reports, the data were evaluated for usability. Analytical data were checked for the following:

- Samples were analyzed within the method specified hold times;
- Samples were received within holding temperature;
- The chain of custody was complete;
- Precision was within SAP control limits using relative percent differences of blind duplicate samples;
- Matrix spike and matrix spike duplicate recoveries and laboratory control samples were within the SAP control limits; and
- Potential for positive bias was evaluated using method blanks concentrations.

Upon completion of the data usability assessment the data were qualified as needed and added to the data tables. All data received were considered complete and usable.

#### **4.3 Statistically Significant Increases Comparison Test**

The baseline monitoring data from the four background wells (B34, B35, B36, and B41) between 2015 and 2017 were previously used to select statistical methods for calculating the range of background concentrations for Appendix III constituents. These data are discussed and presented in the *2017 Annual Groundwater Monitoring and Corrective Action Report* [Geosyntec, 2018a]. The resulting background concentrations are summarized in **Table 5** based upon upper prediction limit (UPL) methods.

In January 2018, the calculated background concentrations were compared to the results of the first Detection Monitoring Sampling Event conducted in October 2017. The comparison of those data to the calculated background concentrations resulted in statistically significant increases (SSIs) over background and triggered an alternate source demonstration.

In July and October 2018, the calculated background concentrations were compared to the results of the April/May 2018 and July/August 2018 Detection Monitoring Sampling Events. The comparison of those to the calculated background concentrations resulted in SSIs over background and triggered a supplemental alternate source demonstration.

#### **4.4 Alternate Source Demonstration**

Following the comparison of calculated background concentrations to the October 2017 detection monitoring concentrations, an *Alternate Source Demonstration Report* [Geosyntec, 2018b] (ASD) was prepared for MD Ash. The ASD concluded that alternative sources (i.e. the adjacent unlined Phase I CCR landfill) had contributed to the SSIs, and that the data did not indicate a release of Appendix III constituents from Phase II. This Report was completed within 180 days of the SSI trigger date and certified by a professional Engineer. The ASD report is included in this Report as **Appendix B**.

#### **4.5 Supplemental Alternative Source Demonstration**

Upon completion of the April/May and July/August 2018 detection monitoring events statistical testing for SSIs over background concentrations was completed. The data indicated that there were SSIs of Appendix III constituents during the 2018 detection monitoring events. Furthermore, increases in boron, calcium, chloride, and sulfate were observed in monitoring wells B16, B27, B37, and B38 compared to the October 2017 samples that were considered by the ASD. A Supplemental Alternate Source Demonstration Report [Geosyntec, 2018c] (SASD) was prepared for MD Ash to discuss the 2018 results, consider possible alternative sources for the SSIs, and provide rationale for whether or not there is a release from the Phase II cell. This Report was completed within 180 days of the SSI trigger date and certified by a professional Engineer. The SASD is provided in this Report as **Appendix C**.

#### **4.6 Transition to Intra-Well Statistical Analysis**

After ASD and SASD were completed and an alternate source for CCB constituents in Phase II compliance well groundwater was identified, the Site statistical analysis was transitioned from inter-well to intra-well statistical analysis [Geosyntec, 2018d]. The intra-well statistical analysis compared groundwater concentrations from each monitoring well against the baseline data collected from the respective well. The intra-well statistical analysis was certified by a professional Engineer. New background concentrations for each Appendix III constituent were calculated for use in next year's annual report. The new background concentrations are presented in **Table 6**.

### **5. DETECTION MONITORING STATISTICS**

In accordance with 40 CFR 257.93(b)(2), detection monitoring statistics were used to evaluate groundwater concentrations of Appendix III constituents collected during the October 2017, April/May 2018, and July/August 2018 detection monitoring events.

SSIs above background were detected in five of the seven compliance groundwater monitoring wells from samples collected during the October 2017 detection monitoring event. SSIs were detected for all Appendix III constituents. SSIs of Appendix III constituents were not detected in monitoring wells B15S and B26.

SSIs above background were detected in five of the seven compliance groundwater monitoring wells from samples collected during the April/May 2018 detection monitoring event. SSIs were detected for all Appendix III constituents, except fluoride. SSIs of Appendix III constituents were not detected in monitoring wells B15S and B26.

SSIs above background were detected in six of the seven compliance groundwater monitoring wells from samples collected during the July/August 2018 detection monitoring event. SSIs were detected for all Appendix III constituents. SSIs of Appendix III constituents were not detected in monitoring well B26.

**Table 5** provides a comparison of the Appendix III detection monitoring results to the calculated background concentrations.

## 6. ASSESSMENT MONITORING STATISTICS

Based on the results of the ASD and SASD the Site is not in assessment monitoring.

## 7. PROBLEMS ENCOUNTERED AND RESOLUTIONS

The following section discusses problems encountered during the Detection Monitoring Program and their resolution.

**Problem 1:** SSIs of Appendix III constituents were detected in the October 2017 detection monitoring event.

**Resolution 1:** An ASD was performed which successfully demonstrated that SSIs in Phase II compliance wells were not due to a release from the Phase II CCR unit, but from the adjacent unlined Phase I unit not regulated under the CCR Rule. As a result, an Assessment Monitoring Program was not initiated, and the Site remained in the Detection Monitoring Program.

**Problem 2:** SSIs of Appendix III constituents were detected from the two 2018 detection monitoring events. Furthermore, some of the 2018 Appendix III parameter concentrations were greater than the initial October 2017 detection monitoring event concentrations that were addressed by the ASD.

**Resolution 2:** An SASD was completed that successfully demonstrated the 2018 SSIs in Phase II compliance wells were not due to a release from the Phase II CCR unit but were from the adjacent unlined Phase I unit not regulated under the CCR Rule.

**Problem 3:** Analytical laboratory data did not concur with field data or other analytical data results. For example, the laboratory measured total dissolved solids did not concur with the field measured specific conductivity and the summation of the laboratory measured cations and anions did not match the laboratory measured total dissolved solids, indicating analytical laboratory error.



**Resolution 3:** Geosyntec worked with the analytical laboratory to correct analytical and reporting errors. Additionally, Geosyntec implemented several additional quality assurance checks to assess the quality of the analytical laboratory data.

## 8. STATUS OF MONITORING PROGRAM

As of December 31, 2018, the Site is currently undergoing detection monitoring and has successfully demonstrated an alternate source of Appendix III constituents in groundwater detected in Phase II compliance wells.

## 9. PLANNED KEY ACTIVITIES FOR 2019

The following section discusses the planned activities for 2019.

**January 2019:** This 2018 Annual Groundwater Monitoring and Corrective Action Report will be entered into the facility's operating record and notification will be sent to the Maryland Department of Environment (MDE).

**February 2019:** Completion of semi-annual detection groundwater monitoring.

**March 2019:** The 2018 Annual Groundwater Monitoring and Corrective Action Report will be posted to the public internet site.

**May/June 2019:** SSI testing of the February 2019 groundwater monitoring results.

**August 2019:** Completion of semi-annual detection groundwater monitoring.

**November/December 2019:** SSI testing of the August 2019 groundwater monitoring results.

**December 2019:** Preparation of the 2019 Annual Groundwater Monitoring and Corrective Action Report will begin.

## 10. REFERENCES

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# TABLES

**TABLE 1  
WELL CONSTRUCTION DETAILS**

**FEDERAL CCR RULE - 2018 ANNUAL GROUNDWATER AND CORRECTIVE ACTION REPORT  
Brandywine Facility Phase II - MD**

Well ID	Compliance / Background	Permit Number	Installation Date	Northing (feet) Maryland State Plane 1900 NAD 1983	Easting (feet) Maryland State Plane 1900 NAD 1983	Ground Surface Elevation (ft msl)	Top of Casing Elevation (ft msl)	Inner Casing Diameter (inches)	Top of Sand Pack (ft bgs)	Screen Interval (ft bgs)	Screen Length (feet)	Screen Slot Size (inch)
B15S	Compliance	PG-11-0414	10/20/2015	376978.815	1368413.012	212.71	214.95	2	6.0	7.75 - 17.75	10	0.010
B16	Compliance	PG-11-0431	6/2/2015	378557.6383	1368348.641	233.73	236.11	2	23.5	24.75 - 34.75	10	0.010
B26	Compliance	PG-11-0416	10/21/2015	377144.555	1367902.054	216.00	218.41	2	14.0	16.75 - 26.75	10	0.010
B27	Compliance	PG-11-0417	6/3/2015	377411.8764	1369043.668	212.05	214.77	2	13.0	14.75 - 24.75	10	0.010
B34	Background	PG-11-0437	6/9/2015	378729.3841	1369777.659	212.73	215.34	2	8.0	10.00 - 20.00	10	0.010
B35	Background	PG-11-0438	6/9/2015	379488.9853	1369866.212	204.31	206.82	2	5.0	7.00 - 17.00	10	0.010
B36	Background	PG-11-0439	6/18/2015	380323.7961	1369560.447	204.25	206.68	2	7.6	9.75 - 19.75	10	0.010
B37	Compliance	PG-11-0461	8/12/2015	377761.92	1367808.354	220.29	220.23	2	17.5	19.75 - 29.75	10	0.010
B38	Compliance	PG-11-0460	8/12/2015	378210.411	1368043.469	233.59	233.66	2	27.5	29.75 - 39.75	10	0.010
B39	Compliance	PG-11-0462	8/10/2015	378222.643	1368948.299	200.56	202.71	2	8.5	10.75 - 20.75	10	0.010
B41	Background	PG-14-0171	9/16/2016	377307.030	1369709.911	209.00	211.50 [1]	2	18.0	20.00 - 30.00	10	0.010

Notes:

ft msl feet above mean sea level

ft bgs feet below ground surface

Professional land survey performed week of 19 October 2015 by Ben Dyer and Associates, Inc.

[1] Elevation is an estimated value

**TABLE 2  
SUMMARY OF 2015-2018 MONITORING EVENTS**

**FEDERAL CCR RULE - 2018 ANNUAL GROUNDWATER AND CORRECTIVE ACTION REPORT  
Brandywine Facility Phase II - MD**

Monitoring Program:	Baseline Monitoring																					
	3Q 2015			4Q 2015			1Q 2016			2Q 2016			3Q 2016			4Q 2016			1Q 2017			
	Sample Date:	Well ID	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17
<b>Background Wells</b>																						
B34														III,IV [1,2]					III,IV	III,IV		III,IV
B35														III,IV [1,2]					III,IV	III,IV		III,IV
B36														III,IV [1,2]					III,IV	III,IV		III,IV
B41														[4]			III,IV [1,2]	[3]	III,IV [1]		III,IV [1,2]	III,IV
<b>Compliance Wells</b>																						
B15S			[4]			III,IV			III,IV			III,IV			III,IV						III,IV	
B16		III,IV [2]			III,IV			III,IV			III,IV			III,IV			III,IV				III,IV [1]	
B26		[4]			III,IV			III,IV			III,IV			III,IV			III,IV				III,IV	
B27		III,IV			III,IV			III,IV			III,IV			III,IV			III,IV				III,IV	
B37		III,IV			III,IV			III,IV			III,IV			III,IV			III,IV					III,IV
B38		III,IV			III,IV			III,IV			III,IV			III,IV			III,IV					III,IV
B39		III,IV			III,IV			III,IV			III,IV			III,IV			III,IV					III,IV

Monitoring Program:	Baseline Monitoring							Total Baseline Sampling Events [5]	Detection Monitoring														
	2Q 2017			3Q 2017			Total Baseline Sampling Events [5]		4Q 2017			1Q 2018			2Q 2018			3Q 2018			Total Detection Sampling Events		
	Sample Date:	Well ID	Apr-17	May-17	Jun-17	Jul-17			Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Jan-18	Feb-18	Mar-19	Apr-18	May-18	Jun-18	Jul-18		Aug-18	Sep-18
<b>Background Wells</b>																							
B34		III,IV	III,IV	III,IV	III,IV	III,IV		≥8	III								III				III		3
B35		III,IV	III,IV	III,IV	III,IV	III,IV		≥8	III						III				III				3
B36		III,IV	III,IV	III,IV	III,IV	III,IV		≥8	III							III			III				3
B41		III,IV	III,IV	III,IV	III,IV	III,IV		≥6	III							III			III				3
<b>Compliance Wells</b>																							
B15S		III,IV			III,IV			8	III							III			III				3
B16		III,IV						8	III						III			III					3
B26		III,IV			III,IV			8	III							III			III				3
B27		III,IV						8	III							III			III				3
B37		III,IV						8	III							III			III				3
B38		III,IV						8	III							III			III				3
B39		III,IV						8	III							III			III				3

Notes:

- III Groundwater samples collected for laboratory analysis of Appendix III parameters.
- IV Groundwater samples collected for laboratory analysis of Appendix IV parameters.
- [1] Radium was omitted from sampling or the well went dry before sampling of these parameters could be completed.
- [2] Fluoride was omitted from analysis.
- [3] Monitoring well was dry at the time of sampling, no samples were collected.
- [4] Monitoring well not yet installed.
- [5] All background and compliance monitoring wells met the minimum number of samples collected, except for B41, which went dry during sampling and only a partial sample set was collected over nine sampling events, which resulted in 6 complete sample sets.

**TABLE 3  
GROUNDWATER ELEVATION MEASUREMENTS**

**FEDERAL CCR RULE - 2018 ANNUAL GROUNDWATER AND CORRECTIVE ACTION REPORT  
Brandywine Facility Phase II - MD**

Well ID	Top of Casing Elevation (ft msl)	Depth to Water Measurement Date	Depth to Water (ft btoic)	Groundwater Elevation (ft msl)
B15S	214.95	1/29/2018	14.14	200.81
		4/30/2018	7.63	207.32
		7/31/2018	6.47	208.48
B16	236.11	1/29/2018	29.55	206.56
		4/30/2018	29.42	206.69
		7/31/2018	29.56	206.55
B26	218.41	1/29/2018	14.14	204.27
		4/30/2018	12.01	206.40
		7/31/2018	11.55	206.86
B27	214.77	1/29/2018	21.87	192.90
		4/30/2018	18.50	196.27
		7/31/2018	18.06	196.71
B34	215.34	1/29/2018	17.31	198.03
		4/30/2018	14.34	201.00
		7/31/2018	12.29	203.05
B35	206.82	1/29/2018	7.97	198.85
		4/30/2018	3.23	203.59
		7/31/2018	3.65	203.17
B36	206.68	1/29/2018	20.45	186.23
		4/30/2018	18.61	188.07
		7/31/2018	17.26	189.42
B37	220.23	1/29/2018	13.43	206.80
		4/30/2018	12.97	207.26
		7/31/2018	12.71	207.52
B38	233.66	1/29/2018	26.64	207.02
		4/30/2018	36.56	197.10
		7/31/2018	26.67	206.99
B39	202.71	1/29/2018	NM	NA
		4/30/2018	10.30	192.41
		7/31/2018	9.76	192.95
B41	211.50 [1]	1/29/2018	28.64	182.86
		4/30/2018	26.09	185.41
		7/31/2018	22.46	189.04

## Notes:

ft bgs feet below ground surface  
ft msl feet above mean sea level  
ft btoic feet below top of inner case

NM Not measured

NA Not Available

[1] Top of casing elevation is estimated value based on ground elevation.

[2] Water levels collected on 29 January 2018 were collected under a separate regulatory program, but included with this report for use in Figure 6.

**TABLE 4**  
**APPENDIX III ANALYTICAL DATA - BACKGROUND WELLS**

**FEDERAL CCR RULE - 2018 ANNUAL GROUNDWATER AND CORRECTIVE ACTION REPORT**  
**Brandywine Facility Phase II - MD**

Analyte:		Boron	Calcium	Chloride	Fluoride	pH	Sulfate	TDS
Well ID	Sample Date	µg/L	mg/L	mg/L	mg/L	S.U.	mg/L	mg/L
B34	5/2/2018	<10.1 U	0.639	3.6	<0.25 U	5.2	7.2	49.0 J
	8/3/2018	13.4 J	2.40	2.4	<0.25 U	5.4	6.4	54.0 J
	8/3/2018 [1]	19.3 J	2.34	2.2	NS	NS	6.4	52.5 J
B35	4/30/2018	<10.1 U	2.40	2.9	<0.25 U	5.6	10.7	37.0 J
	8/2/2018	<12.0 U	1.94	3.4	<0.25 U	5.4	7.0	39.0 J
B36	5/1/2018	15.3 J	4.75	7.0	<0.25 U	5.1	4.7 J	86.5
	8/6/2018	<12.0 U	5.40	7.1	<0.25 U	4.7	16.1	75.5
B41	5/1/2018	<10.1 U	2.93	6.0	<0.25 U	6.0	<1.50 U	47.5 J
	8/6/2018	<12.0 U	4.79	4.7	<0.25 U	3.4 [2] J	21.9	66.0

## Notes:

µg/L micrograms per Liter

mg/L milligrams per Liter

S.U. Standard Units

J Constituent detected below reportable quantitation limit; result is an estimated value.

U Constituent not detected above method detection limit.

N.D. Non-Detect

NS Not Sampled

[1] Duplicate sample collected.

[2] Value is suspected to be erroneous, because the previous 6 samples ranged from 6.1 to 6.6 S.U.

**TABLE 5**  
**APPENDIX III ANALYTICAL DATA - COMPLIANCE WELLS AND SSI COMPARISON**

**FEDERAL CCR RULE - 2018 ANNUAL GROUNDWATER AND CORRECTIVE ACTION REPORT**  
**Brandywine Facility Phase II - MD**

Analyte:		Boron	Calcium	Chloride	Fluoride	pH	Sulfate	TDS
Upper Prediction Limit [1]		25	6.32	14.1 [2]	[3]	3.1 - 7.7	18.6	239
Well ID	Sample Date	µg/L	mg/L	mg/L	mg/L	S.U.	mg/L	mg/L
B15S	10/24/2017	13.6 J	1.93	3.9	<0.25 U	5.0	13.3	39.5
	5/2/2018	14.1 J	1.84	5.4	<0.25 U	5.5	16.7	59.5 J
	5/2/2018 [4]	14.5 J	1.81	5.5	<0.50 U	5.5	16.8	68.0
	8/1/2018	36.4 J	1.60	4.8	0.31 J	5.7	15.0	60.5
B16	10/25/2017	49,500	377	1,580	<0.25 U	6.8	6,410	11,000
	4/30/2018	58,200	426	1,870	<0.25 U	6.7	7,250	13,400
	7/31/2018	53,500	385	1,850	<0.25 U	6.9	8,380	13,400
B26	10/25/2017	17.0 J	4.08	8.8	<0.25 U	4.3	13.2	53.0
	5/1/2018	22.3 J	4.45	10.0	<0.25 U	5.2	12.1	67.5
	8/1/2018	18.6 J	4.85	9.9	<0.25 U	5.2	13.4	59.0 J
B27	10/25/2017	632	427	56.0	<0.25 U	5.9	153	519
	5/1/2018	665	53.9	23.4	<0.25 U	7.0	74.1	419
	8/2/2018	547	41.4	13.4	<0.25 U	7.1	53.7	306
B37	10/24/2017	2,050	104	157	1.0	4.3	624	1,120
	5/1/2018	1,430	90.2	179	0.61	5.0	422	964
	8/3/2018	899	56.1	125	0.39 J	5.2	197	512
B38	10/24/2017	14,900	360	203	0.45 J	6.3	2,530	3,580
	5/1/2018	14,000	421	248	0.25 J	6.4	2,390	3,260
	8/3/2018	14,400	341	225	<0.25 U	6.8	2,360	3,270
B39	10/25/2017	4,870	69.4	426	0.51 J+	2.9 J	1,500	2,200
	10/25/2017 [4]	5,850	69.2	402	0.25 U	3.0 J	1,310	2,120
	5/1/2018	5,280	107	410	<0.25 U	3.1 J	1,350	2,740
	5/1/2018 [4]	4,290	60.3	245	<0.25 U	3.2 J	1,350	1,460
	8/3/2018	5,350	105	420	<0.25 U	2.7 J	1,350	2,200

## Notes:

Detected SSI

µg/L micrograms per Liter

mg/L milligrams per Liter

S.U. Standard Units

J Constituent detected below reportable quantitation limit; result is an estimated value.

J+ Constituent detected below reporting limit; result is an estimated value with a high bias.

U Constituent not detected above method detection limit.

NS Not Sampled

[1] Subject to change as additional data are generated. Calculations provided in Statistical Analysis Calculations Package for Background Groundwater – Phase II, Brandywine Ash Storage Facility, Brandywine, MD (Geosyntec, 2017)

[2] The background dataset has a lognormal distribution but does not display equal variance; thus, were calculated using nonparametric methods (Unified Guidance, 2009).

[3] The Double Quantification Rule (DQR) is used for background data sets with no detections.

[4] Duplicate sample collected.



**TABLE 6**  
**APPENDIX III INTRA-WELL STATISICAL BACKGROUND CONCENTRATIONS**  
**FEDERAL CCR RULE - 2018 ANNUAL GROUNDWATER AND CORRECTIVE ACTION REPORT**  
**Brandywine Facility Phase II - MD**

Analyte:	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	TDS
Well ID	µg/L	mg/L	mg/L	mg/L	S.U.	mg/L	mg/L
B15S	43.4	5.58	12.4	DQR [1]	3.84 - 6.71	41.7	121
B16	59,057	497	2,950	DQR [1]	5.76 - 7.48	791 [2]	16,227
B26	124	11.7	20.6	DQR [1]	5.90	62.9	213
B27	1,494	59.6	233	0.47	4.87 - 8.40	654	1,247
B37	4,011	213	32.9 [2]	2.21	2.90 - 5.87	779	2,559
B38	27,194	566	810	1.04	4.08 - 9.01	2,540	5,185
B39	1,346	188	59.8 [2]	2.87	2.01 - 4.20	184 [2]	364 [2]

Notes:

µg/L micrograms per Liter

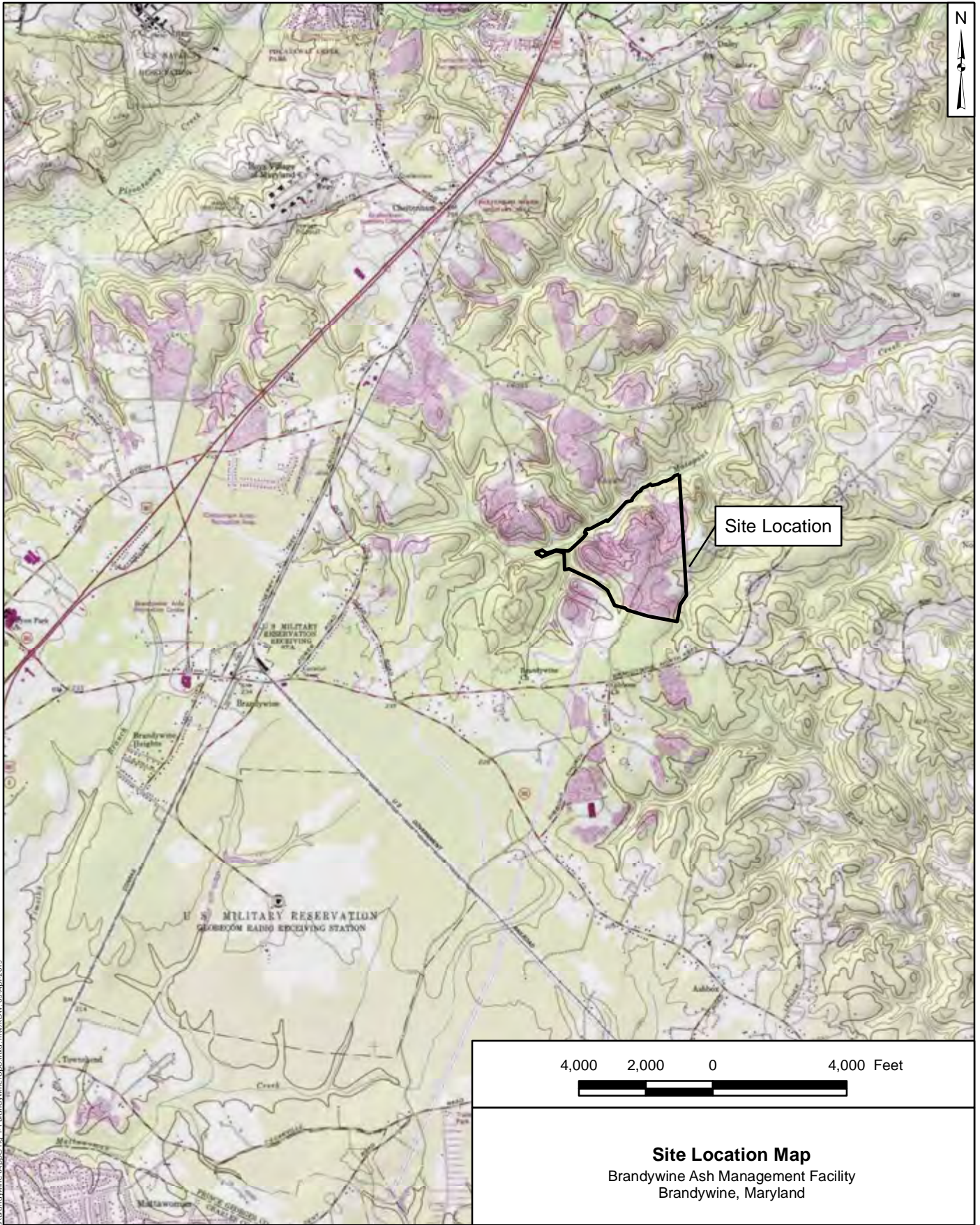
mg/L milligrams per Liter

S.U. Standard Units

[1] Fluoride at wells B15S, B16, and B26 follows the Double Quantification Rule (DQR).

[2] The background value is the Upper Prediction Limit (UPL) for the residuals of the background dataset. To identify SSIs, the UPLs are compared to the residuals of the detection monitoring results based on the linear regression for the background dataset.

# FIGURES



Site Location

4,000 2,000 0 4,000 Feet



**Site Location Map**  
 Brandywine Ash Management Facility  
 Brandywine, Maryland

Source:  
 USGS Topographic Quadrangle - Brandywine, Maryland,  
 provided by the National Geographic Society and i-cubed. © 2011  
 National Geographic Society, i-cubed

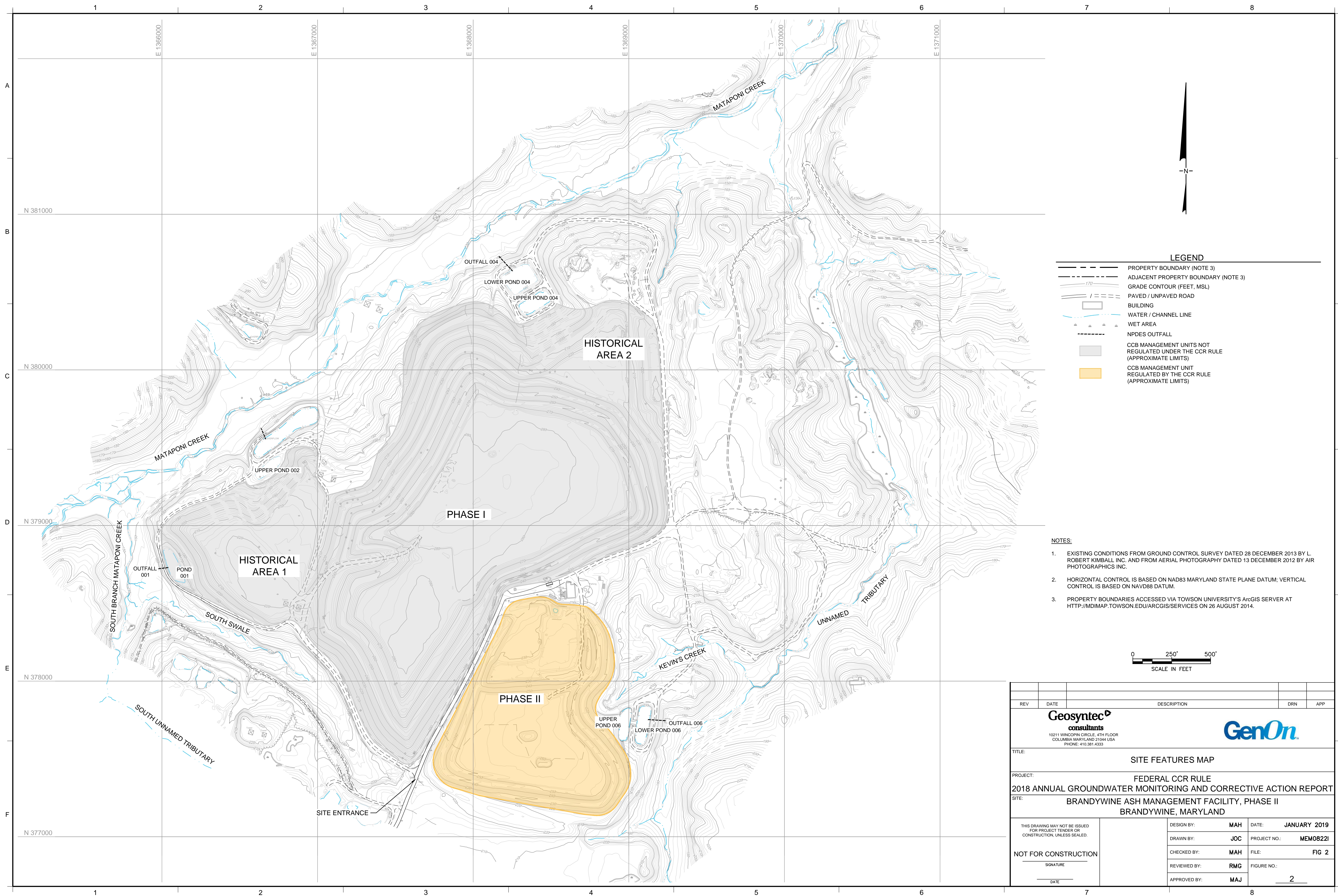
**Geosyntec**  
 consultants

Figure

1

Columbia, Maryland

January 2019

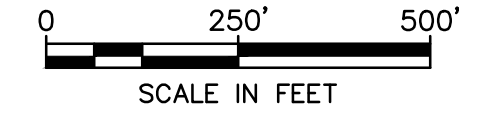


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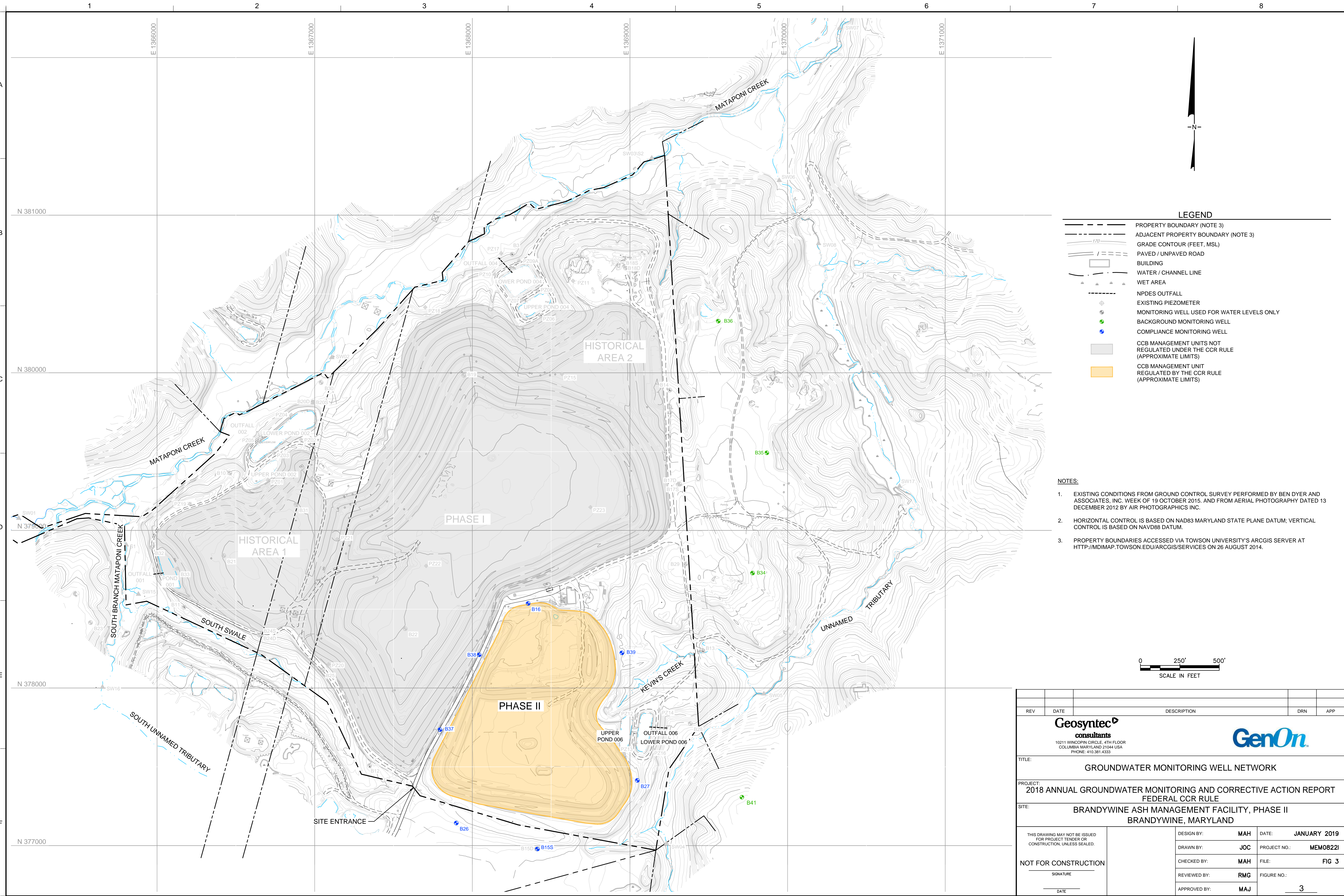
- PROPERTY BOUNDARY (NOTE 3)
- ADJACENT PROPERTY BOUNDARY (NOTE 3)
- GRADE CONTOUR (FEET, MSL)
- PAVED / UNPAVED ROAD
- BUILDING
- WATER / CHANNEL LINE
- WET AREA
- NPDES OUTFALL
- CCB MANAGEMENT UNITS NOT REGULATED UNDER THE CCR RULE (APPROXIMATE LIMITS)
- CCB MANAGEMENT UNIT REGULATED BY THE CCR RULE (APPROXIMATE LIMITS)

**NOTES:**

1. EXISTING CONDITIONS FROM GROUND CONTROL SURVEY DATED 28 DECEMBER 2013 BY L. ROBERT KIMBALL INC. AND FROM AERIAL PHOTOGRAPHY DATED 13 DECEMBER 2012 BY AIR PHOTOGRAPHICS INC.
2. HORIZONTAL CONTROL IS BASED ON NAD83 MARYLAND STATE PLANE DATUM; VERTICAL CONTROL IS BASED ON NAVD88 DATUM.
3. PROPERTY BOUNDARIES ACCESSED VIA TOWSON UNIVERSITY'S ArcGIS SERVER AT [HTTP://MDIMAP.TOWSON.EDU/ARCGIS/SERVICES](http://mdimap.towson.edu/arcgis/services) ON 26 AUGUST 2014.



REV	DATE	DESCRIPTION	DRN	APP	
 10211 WINDOPIN CIRCLE, 4TH FLOOR COLUMBIA MARYLAND 21044 USA PHONE: 410.381.4333					
<b>TITLE:</b> SITE FEATURES MAP					
<b>PROJECT:</b> FEDERAL CCR RULE 2018 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT					
<b>SITE:</b> BRANDYWINE ASH MANAGEMENT FACILITY, PHASE II BRANDYWINE, MARYLAND					
THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION UNLESS SEALED.  <b>NOT FOR CONSTRUCTION</b> SIGNATURE _____ DATE _____		DESIGN BY:	<b>MAH</b>	DATE:	<b>JANUARY 2019</b>
		DRAWN BY:	<b>JOC</b>	PROJECT NO.:	<b>MEM08221</b>
		CHECKED BY:	<b>MAH</b>	FILE:	<b>FIG 2</b>
		REVIEWED BY:	<b>RMG</b>	FIGURE NO.:	
		APPROVED BY:	<b>MAJ</b>		<b>2</b>

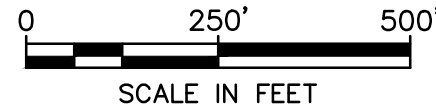


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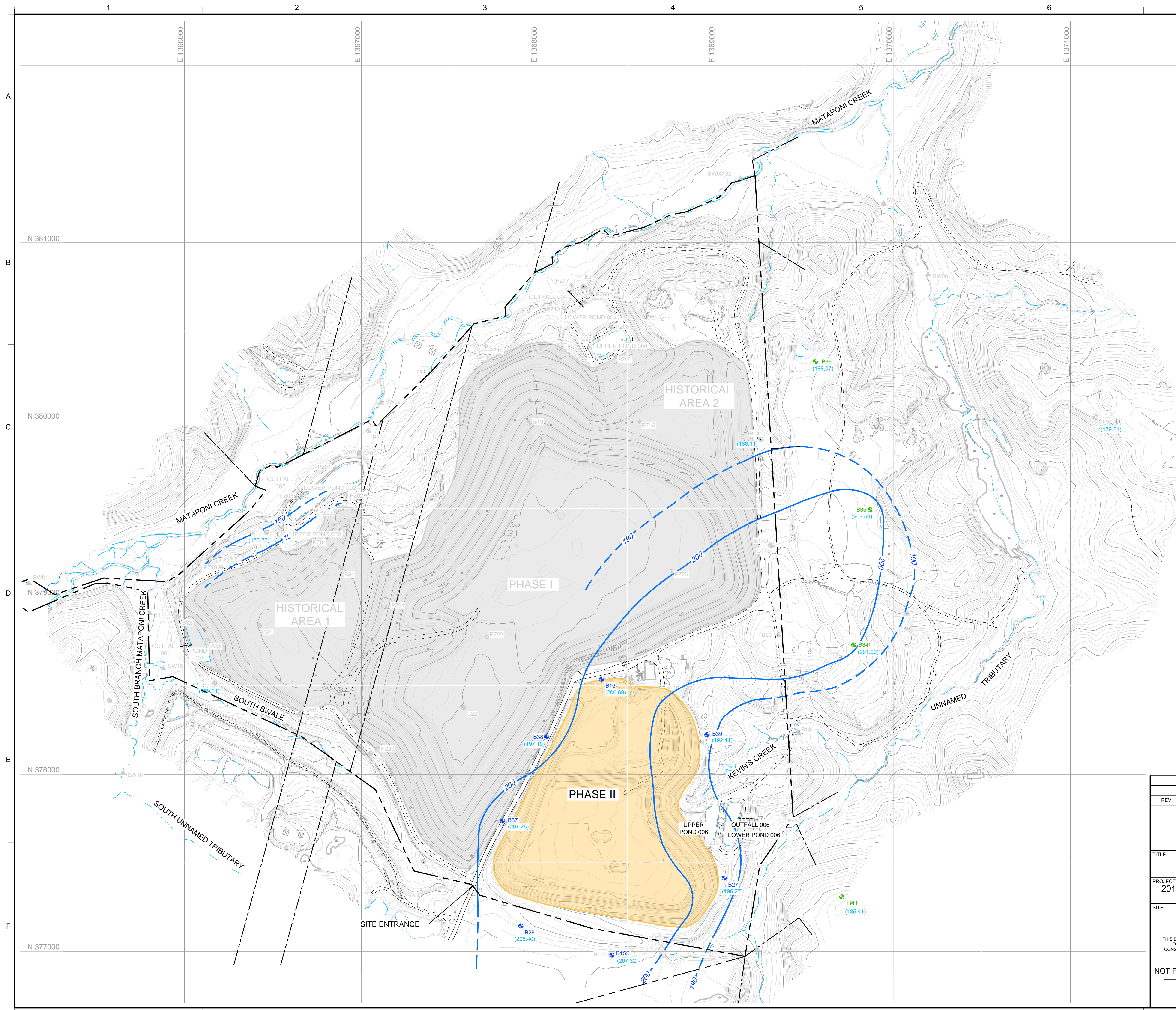
- PROPERTY BOUNDARY (NOTE 3)
- ADJACENT PROPERTY BOUNDARY (NOTE 3)
- GRADE CONTOUR (FEET, MSL)
- PAVED / UNPAVED ROAD
- BUILDING
- WATER / CHANNEL LINE
- WET AREA
- NPDES OUTFALL
- EXISTING PIEZOMETER
- MONITORING WELL USED FOR WATER LEVELS ONLY
- BACKGROUND MONITORING WELL
- COMPLIANCE MONITORING WELL
- CCB MANAGEMENT UNITS NOT REGULATED UNDER THE CCR RULE (APPROXIMATE LIMITS)
- CCB MANAGEMENT UNIT REGULATED BY THE CCR RULE (APPROXIMATE LIMITS)

**NOTES:**

1. EXISTING CONDITIONS FROM GROUND CONTROL SURVEY PERFORMED BY BEN DYER AND ASSOCIATES, INC. WEEK OF 19 OCTOBER 2015, AND FROM AERIAL PHOTOGRAPHY DATED 13 DECEMBER 2012 BY AIR PHOTOGRAPHICS INC.
2. HORIZONTAL CONTROL IS BASED ON NAD83 MARYLAND STATE PLANE DATUM; VERTICAL CONTROL IS BASED ON NAVD88 DATUM.
3. PROPERTY BOUNDARIES ACCESSED VIA TOWSON UNIVERSITY'S ARCGIS SERVER AT [HTTP://MDIMAP.TOWSON.EDU/ARCGIS/SERVICES](http://mdimap.towson.edu/arcgis/services) ON 26 AUGUST 2014.

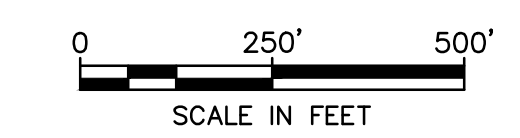


REV	DATE	DESCRIPTION	DRN	APP
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PROJECT: 2018 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT FEDERAL CCR RULE				
SITE: BRANDYWINE ASH MANAGEMENT FACILITY, PHASE II BRANDYWINE, MARYLAND				
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		DRAWN BY: <b>JOC</b>	PROJECT NO.: <b>MEM0822I</b>	
		CHECKED BY: <b>MAH</b>	FILE: <b>FIG 3</b>	
		REVIEWED BY: <b>RMG</b>	FIGURE NO.:	
		APPROVED BY: <b>MAJ</b>	3	
NOT FOR CONSTRUCTION		SIGNATURE _____		
		DATE _____		

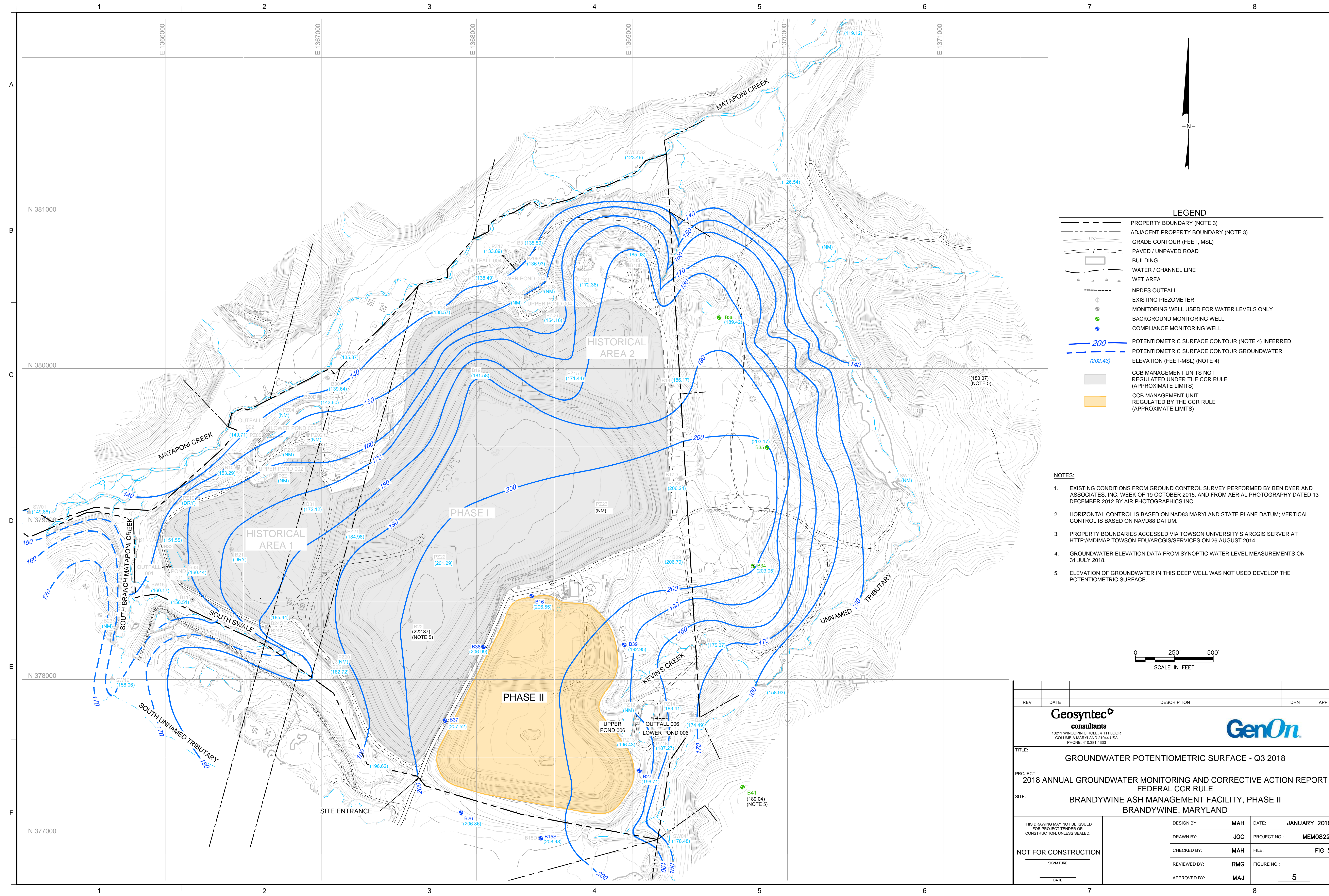


- ### LEGEND
- PROPERTY BOUNDARY (NOTE 3)
  - ADJACENT PROPERTY BOUNDARY (NOTE 3)
  - GRADE CONTOUR (FEET, MSL)
  - PAVED / UNPAVED ROAD
  - BUILDING
  - WATER / CHANNEL LINE
  - WET AREA
  - NPDES OUTFALL
  - EXISTING PIEZOMETER
  - MONITORING WELL USED FOR WATER LEVELS ONLY
  - BACKGROUND MONITORING WELL
  - COMPLIANCE MONITORING WELL
  - POTENTIOMETRIC SURFACE CONTOUR (NOTE 4)
  - INFERRER POTENTIOMETRIC SURFACE CONTOUR (202.43)
  - GROUNDWATER ELEVATION (FEET-MSL) (NOTE 4)
  - CCB MANAGEMENT UNITS NOT REGULATED UNDER THE CCR RULE (APPROXIMATE LIMITS)
  - CCB MANAGEMENT UNIT REGULATED BY THE CCR RULE (APPROXIMATE LIMITS)

- ### NOTES:
1. EXISTING CONDITIONS FROM GROUND CONTROL SURVEY PERFORMED BY BEN DYER AND ASSOCIATES, INC. WEEK OF 19 OCTOBER 2015, AND FROM AERIAL PHOTOGRAPHY DATED 13 DECEMBER 2012 BY AIR PHOTOGRAPHICS INC.
  2. HORIZONTAL CONTROL IS BASED ON NAD83 MARYLAND STATE PLANE DATUM; VERTICAL CONTROL IS BASED ON NAVD88 DATUM.
  3. PROPERTY BOUNDARIES ACCESSED VIA TOWSON UNIVERSITY'S ARCGIS SERVER AT [HTTP://MDIMAP.TOWSON.EDU/ARCCGIS/SERVICES](http://mdimap.towson.edu/arccgis/services) ON 26 AUGUST 2014.
  4. GROUNDWATER ELEVATION DATA FROM SYNOPTIC WATER LEVEL MEASUREMENTS ON 30 APRIL 2018.
  5. ELEVATION OF GROUNDWATER IN THIS DEEP WELL WAS NOT USED DEVELOP THE POTENTIOMETRIC SURFACE.



 10211 WINDOPWY CIRCLE, 4TH FLOOR COLUMBIA MARYLAND 21044 USA PHONE: 410.381.4333					
TITLE: GROUNDWATER POTENTIOMETRIC SURFACE - Q2 2018					
PROJECT: 2018 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT FEDERAL CCR RULE					
SITE: BRANDYWINE ASH MANAGEMENT FACILITY, PHASE II BRANDYWINE, MARYLAND					
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		DRAWN BY: JOC		PROJECT NO.: MEM0822I	
		CHECKED BY: MAH		FILE: FIG 4	
		REVIEWED BY: RMG		FIGURE NO.: 4	
		APPROVED BY: MAJ			
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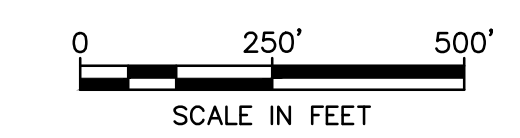


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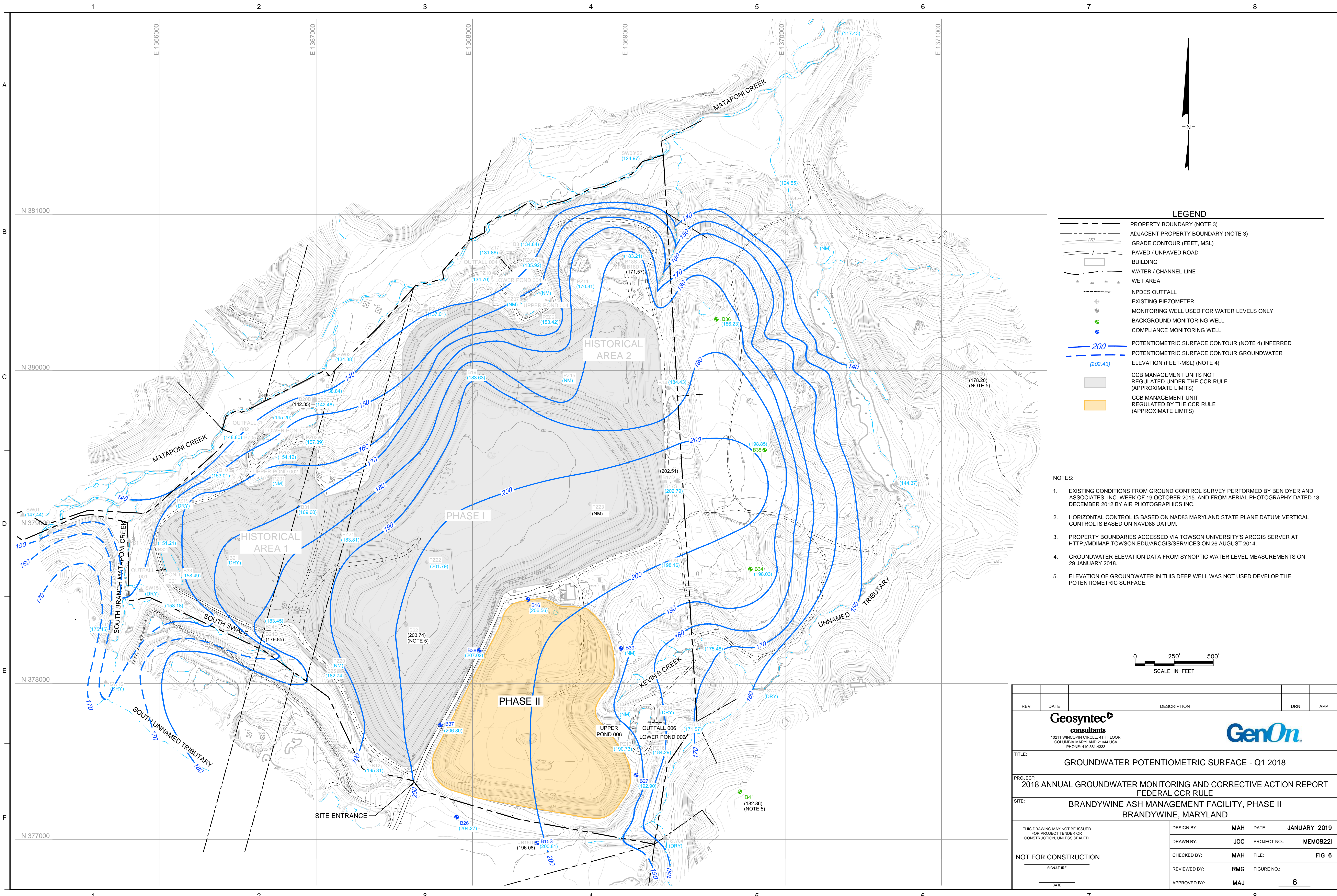
- PROPERTY BOUNDARY (NOTE 3)
- ADJACENT PROPERTY BOUNDARY (NOTE 3)
- GRADE CONTOUR (FEET, MSL)
- PAVED / UNPAVED ROAD
- BUILDING
- WATER / CHANNEL LINE
- WET AREA
- NPDES OUTFALL
- EXISTING PIEZOMETER
- MONITORING WELL USED FOR WATER LEVELS ONLY
- BACKGROUND MONITORING WELL
- COMPLIANCE MONITORING WELL
- 200 POTENTIOMETRIC SURFACE CONTOUR (NOTE 4) INFERRED
- 202.43 POTENTIOMETRIC SURFACE CONTOUR GROUNDWATER ELEVATION (FEET-MSL) (NOTE 4)
- CCB MANAGEMENT UNITS NOT REGULATED UNDER THE CCR RULE (APPROXIMATE LIMITS)
- CCB MANAGEMENT UNIT REGULATED BY THE CCR RULE (APPROXIMATE LIMITS)

**NOTES:**

1. EXISTING CONDITIONS FROM GROUND CONTROL SURVEY PERFORMED BY BEN DYER AND ASSOCIATES, INC. WEEK OF 19 OCTOBER 2015, AND FROM AERIAL PHOTOGRAPHY DATED 13 DECEMBER 2012 BY AIR PHOTOGRAPHICS INC.
2. HORIZONTAL CONTROL IS BASED ON NAD83 MARYLAND STATE PLANE DATUM; VERTICAL CONTROL IS BASED ON NAVD88 DATUM.
3. PROPERTY BOUNDARIES ACCESSED VIA TOWSON UNIVERSITY'S ARCGIS SERVER AT HTTP://MDIMAP.TOWSON.EDU/ARCGIS/SERVICES ON 26 AUGUST 2014.
4. GROUNDWATER ELEVATION DATA FROM SYNOPTIC WATER LEVEL MEASUREMENTS ON 31 JULY 2018.
5. ELEVATION OF GROUNDWATER IN THIS DEEP WELL WAS NOT USED DEVELOP THE POTENTIOMETRIC SURFACE.



REV	DATE	DESCRIPTION	DRN	APP
<small>10211 WINDOORN CIRCLE, 4TH FLOOR COLUMBIA MARYLAND 21044 USA PHONE: 410.381.4333</small>				
<b>TITLE: GROUNDWATER POTENTIOMETRIC SURFACE - Q3 2018</b>				
<b>PROJECT: 2018 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT FEDERAL CCR RULE</b>				
<b>SITE: BRANDYWINE ASH MANAGEMENT FACILITY, PHASE II BRANDYWINE, MARYLAND</b>				
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		CHECKED BY: <b>MAH</b>	FILE: <b>FIG 5</b>	
		REVIEWED BY: <b>RMG</b>	FIGURE NO.:	
		APPROVED BY: <b>MAJ</b>	<b>5</b>	

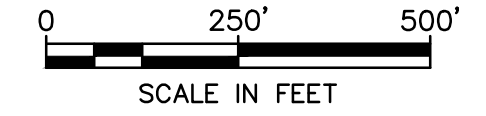


**LEGEND**

- PROPERTY BOUNDARY (NOTE 3)
- ADJACENT PROPERTY BOUNDARY (NOTE 3)
- GRADE CONTOUR (FEET, MSL)
- PAVED / UNPAVED ROAD
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- NPDES OUTFALL
- EXISTING PIEZOMETER
- MONITORING WELL USED FOR WATER LEVELS ONLY
- BACKGROUND MONITORING WELL
- COMPLIANCE MONITORING WELL
- POTENTIOMETRIC SURFACE CONTOUR (NOTE 4) INFERRED
- POTENTIOMETRIC SURFACE CONTOUR GROUNDWATER
- ELEVATION (FEET-MSL) (NOTE 4)
- CCB MANAGEMENT UNITS NOT REGULATED UNDER THE CCR RULE (APPROXIMATE LIMITS)
- CCB MANAGEMENT UNIT REGULATED BY THE CCR RULE (APPROXIMATE LIMITS)

**NOTES:**

1. EXISTING CONDITIONS FROM GROUND CONTROL SURVEY PERFORMED BY BEN DYER AND ASSOCIATES, INC. WEEK OF 19 OCTOBER 2015, AND FROM AERIAL PHOTOGRAPHY DATED 13 DECEMBER 2012 BY AIR PHOTOGRAPHICS INC.
2. HORIZONTAL CONTROL IS BASED ON NAD83 MARYLAND STATE PLANE DATUM; VERTICAL CONTROL IS BASED ON NAVD88 DATUM.
3. PROPERTY BOUNDARIES ACCESSED VIA TOWSON UNIVERSITY'S ARCGIS SERVER AT [HTTP://MDIMAP.TOWSON.EDU/ARCGIS/SERVICES](http://mdimap.towson.edu/arcgis/services) ON 26 AUGUST 2014.
4. GROUNDWATER ELEVATION DATA FROM SYNOPSIS WATER LEVEL MEASUREMENTS ON 29 JANUARY 2018.
5. ELEVATION OF GROUNDWATER IN THIS DEEP WELL WAS NOT USED DEVELOP THE POTENTIOMETRIC SURFACE.



REV	DATE	DESCRIPTION	DRN	APP
<small>10211 WINDOORN CIRCLE, 4TH FLOOR COLUMBIA MARYLAND 21044 USA PHONE: 410.381.4333</small>				
<b>TITLE:</b> GROUNDWATER POTENTIOMETRIC SURFACE - Q1 2018				
<b>PROJECT:</b> 2018 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT FEDERAL CCR RULE				
<b>SITE:</b> BRANDYWINE ASH MANAGEMENT FACILITY, PHASE II BRANDYWINE, MARYLAND				
THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.		DESIGN BY: MAH	DATE: JANUARY 2019	
<b>NOT FOR CONSTRUCTION</b>		DRAWN BY: JOC	PROJECT NO.: MEM0822I	
		CHECKED BY: MAH	FILE: FIG 6	
		REVIEWED BY: RMG	FIGURE NO.:	
		APPROVED BY: MAJ	6	
SIGNATURE _____				
DATE _____				

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## APPENDIX A

### Groundwater Flow Velocity Calculation

## Appendix A

### Groundwater Velocity Calculation

Brandywine Ash Management Facility Phase II

Brandywine, Maryland

#### 1. Governing Equation

Groundwater flow velocity at the Site was calculated between several monitoring wells around Phase II of the Site. The calculations were performed using the following equation.

$$V_{\eta} = \frac{K}{\eta} \times \frac{\Delta h}{\Delta l}$$

Where:

$V_{\eta}$  = Groundwater velocity (cm per second)

$K$  = Hydraulic conductivity estimated through aquifer slug tests (cm per second)

$\eta$  = Effective porosity % (unitless)

$\Delta h$  = Change in groundwater elevation between two points (ft)

$\Delta l$  = Distance between two points (ft)

This equation is for Darcy flow through porous media.

#### 2. Hydraulic Conductivity Estimated

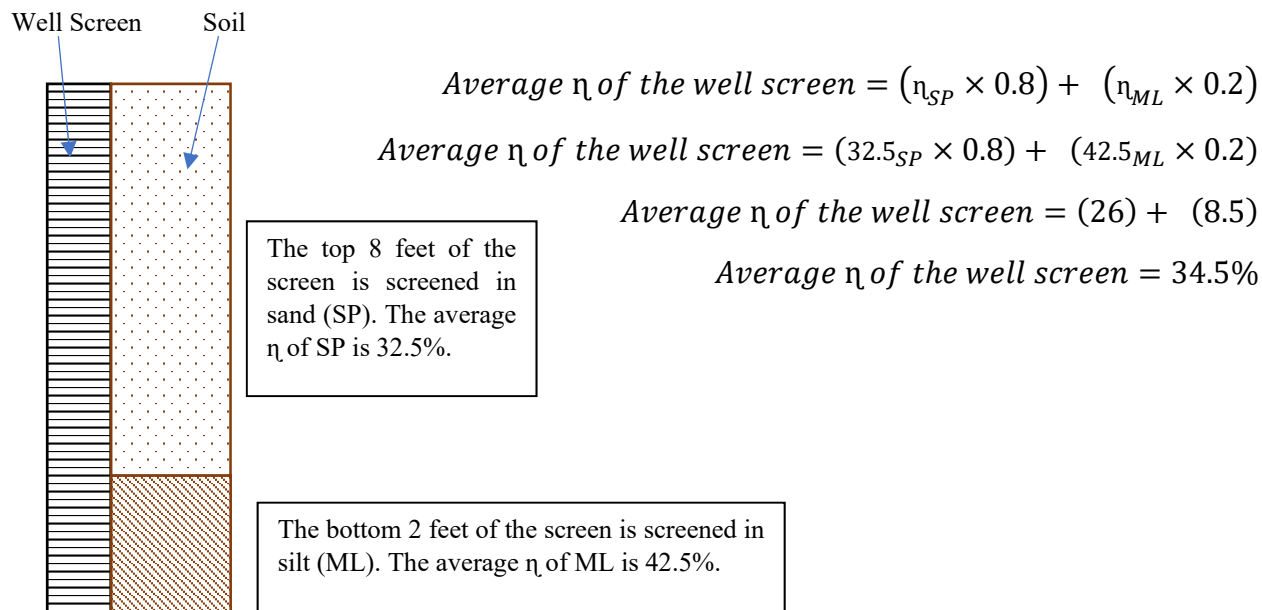
Hydraulic conductivity ( $K$ ) was calculated at select monitoring wells around Phase II. Monitoring wells B15S, B16, B26, B27, and B28 were slug tested at least two times (rising and falling head tests). The location of the slug tested wells are shown on **Figure 3**. The  $K$  value for each slug test at a given well was averaged, which generated an average  $K$  for each monitoring well.  $K$  values are presented in **Table A-1**. The average of the  $K$  value between two monitoring wells is presented on **Table A-2**.

#### 3. Average Porosity

As shown on **Table A-1**, each monitoring well has an average porosity ( $\eta$ ) calculated for each screen interval. The averaged  $\eta$  values were obtained from *Groundwater and Wells, Second Edition, Driscoll* [Driscoll, 1986]. A range for  $\eta$  is presented in [Driscoll, 1986] and the average for each  $\eta$  range was used in the calculation. The published  $\eta$  values and the calculated average  $\eta$  values are presented on **Table A-1**.

The averaged  $\eta$  value was then used to estimate an  $\eta$  value for each screen based on the geology observed during the well installation. See diagram below to see how  $\eta$  was estimated for each monitoring well screen.

### EXAMPLE POROSITY ESTIMATION FOR WELL SCREEN



Boring logs were provided in *Basis for Groundwater Monitoring Network* [Geosyntec, 2017a].

After the average  $\eta$  value was calculated for each well screen, the average of the  $\eta$  values between the two monitoring wells along a groundwater flow path was calculated. See **Table A-1** for the calculated average  $\eta$  for each monitoring well screen. The average  $\eta$  value between the two monitoring wells was then used to calculate the groundwater velocity. Average  $\eta$  value between monitoring wells is presented on **Table A-2**.

#### **4. Monitoring Well Selection**

To estimate groundwater velocity, monitoring wells upgradient and downgradient of Phase II were selected. Ideally, monitoring wells should be along a groundwater flow path. Based on that requirement, the groundwater velocity was calculated between B16 to B27, B16 to B28, B26 to B27, and B26 to B28. See **Figure 3** to **Figure 5** for the selected well locations relative to groundwater flow.

#### **5. Groundwater Velocity**

Groundwater velocity around Phase II ranged from  $1.39 \times 10^{-4}$  centimeters per second (cm/sec) (144 inches/month) between monitoring wells B16 and B28 to  $4.13 \times 10^{-6}$  cm/sec (427 inches/month) between monitoring wells B26 and B27. The average groundwater velocity around Phase II was calculated at  $2.55 \times 10^{-5}$  cm/sec (26 inches/month). **Table A-2** of **Appendix A** presents the calculated groundwater velocities. Therefore, to be considered independent samples, groundwater monitoring events should be at least two (2) weeks apart for groundwater to completely travel through the 8-inch diameter borehole.

**APPENDIX A**  
**TABLE A-1**  
**Groundwater Flow Velocity Variables**

**Brandywine CCR Management Facility Phase II**  
**Brandywine, Maryland**

Groundwater Velocity Equation

$$V_{\eta} = \frac{K}{\eta} \times \frac{\Delta h}{\Delta l}$$

$V_{\eta}$  = linear groundwater velocity (cm/sec)

$K$  = hydraulic conductivity (cm/sec)

$\eta$  = effective porosity (unitless)

$\Delta h$  = change in head between wells (ft)

$\Delta l$  = distance between wells (ft)

Upgradient Well	Downgradient Well	$\Delta l$ (ft)	$\Delta h$ (ft)
B16	B27	1,315	9.84
B16	B28	1,270	32.06
B26	B27	1,172.5	10.15
B26	B28	1,612.5	32.37

Well ID:	Average Hydraulic Conductivity ( $K$ ) (cm/sec) [1]
B16	2.81E-03
B26	5.50E-06
B27	3.85E-04
B28	8.17E-04

Well Location	Soil Observed in the Screen	Average $\eta$ of Screen
B16	(SP/GP) (75%),(SP/ML) (25%)	24.5
B26	ML 100%	42.5
B27	ML/SP 50% and CL/SP 50%	39.4
B28	SP/CL 100%	41.3

Sediment Size	Effective Porosity % ( $\eta$ )	Average $\eta$ [2]
Clay (CL)	45-55	50
Silt (ML)	35-50	42.5
Sand (SP)	25-40	32.5
Gravel (GP)	25-40	32.5
Sand and Gravel (SP/GP)	10-35	22.5

Notes:

ft - feet

cm/sec - centimeters per second

[1] Average hydraulic conductivity is an average result of the falling and rising head slug tests.

[2] Average effective porosity is an average of the published effective porosities for each soil type.

[3]  $\Delta l$  values were calculated from groundwater elevation measurements collected on 31 July 2018.

APPENDIX A  
Table A-2  
Groundwater Flow Velocity Calculation

Brandywine CCR Management Facility Phase II  
Brandywine, Maryland

Upgradient Well	Downgradient Well	Hydraulic Conductivity (K) (cm/sec)	Average Porosity of Screen Interval (%)	DTW (ft btoic) [1]	TOC Elevation	Groundwater Elevation (ft-msl)	Average K (cm/sec) [2]	Average $\eta$	$\Delta h$ (ft)	$\Delta l$ (ft)	$\Delta h/\Delta l$	Linear Velocity (cm/sec)	Linear Velocity (inches/month)
B16	B27	3.85E-04	39.4	18.06	214.77	196.71	1.60E-03	0.3195	9.84	1,315	0.0075	3.74E-05	38.71
B16	B28	8.17E-04	41.3	5.29	179.78	174.49	1.81E-03	0.329	32.06	1,270	0.0252	1.39E-04	143.97

Upgradient Well	Downgradient Well	Hydraulic Conductivity (K) (cm/sec)	Average Porosity of Screen Interval (%)	DTW (ft btoic)	TOC Elevation	Groundwater Elevation (ft-msl)	Average K (cm/sec) [1]	Average $\eta$	$\Delta h$ (ft)	$\Delta l$ (ft)	$\Delta h/\Delta l$	Linear Velocity (cm/sec)	Linear Velocity (inches/month)
B26	B27	3.85E-04	39.4	18.06	214.77	196.71	1.95E-04	0.4095	10.15	1,173	0.0087	4.13E-06	4.27
B26	B28	8.17E-04	41.3	5.29	179.78	174.49	4.11E-04	0.419	32.37	1,613	0.0201	1.97E-05	20.39

Groundwater Velocity Equation

$$V_n = \frac{K}{\eta} \times \frac{\Delta h}{\Delta l}$$

$V_n$  = linear groundwater velocity

$K$  = hydraulic conductivity (cm/sec)

$\eta$  = effective porosity (unitless)

$\Delta h$  = change in head between wells (ft)

$\Delta l$  = distance between wells (ft)

[1] Groundwater flow velocities were calculated from groundwater elevation measurements collected on 31 July 2018.

[2] Average hydraulic conductivity is the average hydraulic conductivities between B16 or B26 and identified well.

<b>Groundwater Velocity Mean</b>	<b>2.55E-05 cm/sec</b>	<b>26.39 inches/month</b>
<b>Groundwater Velocity Median</b>	<b>2.86E-05 cm/sec</b>	<b>29.55 inches/month</b>

# APPENDIX B

## Alternate Source Demonstration

*Prepared for*



**GenOn MD Ash Management LLC**

25100 Chalk Point Road  
Aquasco, Maryland

# **ALTERNATE SOURCE DEMONSTRATION REPORT**

## **FEDERAL CCR RULE BRANDYWINE ASH MANAGEMENT FACILITY PHASE II, BRANDYWINE, MARYLAND**

*Prepared by*

**Geosyntec** 

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Project Number MEM0822H

16 July 2018

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## **1. INTRODUCTION**

The Federal Coal Combustion Residuals (CCR) Rule provides an opportunity under Title 40 Code of Federal Regulations (CFR) Part 257.94(e)(2) for the owner/operator of a regulated CCR unit to demonstrate that a statistically significant increase (SSI) above background concentrations of Appendix III constituents during the Detection Monitoring Program is from a source other than the CCR unit. An SSI for one or more Appendix III constituents is a potential indication of a release of CCR constituents to groundwater. If it can be demonstrated that the SSIs are due to an error (i.e., sampling error, laboratory error, statistical analysis error), due to natural variation in groundwater quality, or due to an alternate source (other than the regulated CCR unit), then the CCR unit may remain in the Detection Monitoring Program. If a successful alternate source demonstration is not made, or if a successful demonstration is not completed within 180 days of an SSI trigger date, then the CCR unit must initiate an Assessment Monitoring Program (USEPA, 2018). If a successful demonstration is completed more than 180 days after the SSI trigger date, the CCR unit may return to the Detection Monitoring Program at that time. The Federal CCR Rule does not contain requirements nor reference agency guidance for a successful alternate source demonstration other than certification of its accuracy by a Professional Engineer.

Geosyntec Consultants, Inc. (Geosyntec) has prepared this Alternate Source Demonstration (ASD) Report for the Phase II landfill CCR unit (referred to herein as the site, the landfill, and the CCR unit) at the Brandywine Ash Management Facility in Brandywine, Maryland. This ASD Report demonstrates that a source other than the regulated CCR unit is responsible for SSIs of Appendix III constituents in October 2017 Detection Monitoring Program samples collected from the downgradient compliance wells around Phase II. This ASD Report was completed and certified by a Professional Engineer within 180 days of the SSI trigger date.

## **2. SITE DESCRIPTION**

### **2.1 Site Description**

The Site is located on the Atlantic Coastal Plain province in Brandywine, Prince George's County, Maryland (**Figure 1**) and is operated by GenOn MD Ash Management LLC (MD Ash). Features of the Site and their locations are presented on **Figure 2**. It was previously mined for sand and gravel and began accepting CCR in the 1970s. It encompasses 217 acres of which approximately 140 acres have been used to manage CCR.

The Site was developed for CCR management in stages in accordance with various engineering design documents. The initial areas of Site development included Historical Area 1 (17.1 acres), Historical Area 2 (11.4 acres), and Phase I (81.9 acres), all of which are inactive, unlined, and have recently had their vegetative closure covers replaced by geosynthetic caps. Phase II (29 acres) was developed last, is currently active, and is the only CCR unit at the site regulated by the Federal CCR Rule.

Phase II was constructed with a polyvinylchloride (PVC) bottom liner that is overlain by an 18-inch thick leachate collection system meeting the requirements of Code of Maryland Regulations (COMAR) 26.04.10. The PVC liner was installed on top of a one-foot thick layer of compacted clay. The leachate collection system includes perforated pipes that convey leachate to buried high density polyethylene (HDPE) conveyance pipes that drain by gravity to an outfall above the water level in Pond 006 directly to the east. The leachate collection pipes were sized and spaced so that the leachate depth over the liner does not exceed one foot. Non-contact storm water runoff is directed away from Phase II through perimeter ditches and berms.

### **2.2 Operational History**

In 1971, the J.E. Greiner Company (Greiner) was contracted to prepare a plan to develop the property for CCR management. In 1975, the development plan prepared by Greiner was modified by GAI Consultants (GAI) to include a placement grading plan with storm water management features such as drainage swales and sedimentation ponds.

Historical Area 1 and Historical Area 2 were nearing their design capacity by 1975 and CCR was managed in Phase I from 1975 through 2008 (URS, 2009). Phase I was filled with CCR to the final design grade by 2008 and closed with a vegetated soil cover system. Review of historical aerial photographs indicates that CCR was temporarily staged in the future Phase II area during Phase I operations. The extent and depth of staged CCR materials at the Phase II area were evaluated by a 2007 test pit program (GAI, 2007). The Phase II design specified relocation of all CCR (estimated to be approximately 130,000 cubic yards), including CCR below the future liner elevation and six inches of over-excavation, prior to construction of the Phase II liner system (GAI, 2008).

Phase II is divided into two cells, Phase IIA and Phase IIB. Phase IIB was constructed first with liner installation from June 2007 through November 2007 under a construction quality assurance quality control plan (GAI, 2008). Starting in 2008, CCR was managed in Phase II which was

constructed as a modern lined waste disposal cell with a geosynthetic bottom liner and leachate collection system.

Construction of a modern geosynthetic cap for Historical Area 1, Historical Area 2, and Phase I was initiated in the spring of 2015 and was completed in early 2018. In addition to capping, Site-wide storm water controls and leachate management/treatment systems were upgraded. A truck wash is located adjacent to the site trailer along the haul road between Phase 1 and Phase II and has been in operation since prior to 1984 (ERM, 1984). The truck wash uses the existing deep well from the prior farm house as a water source. That well draws water from a deep aquifer below the regional Calvert Formation confining unit.

### **2.3 CCR Units Regulated by the Federal CCR Rule**

Phase II is a dry ash management operation and does not include CCR surface impoundments (SI) as defined in the Federal CCR Rule. Phase I and Historical Area 1 and 2 were inactive and closed landfills by 2015 and therefore are exempt from regulation under the Federal CCR Rule. Phase II is an existing CCR landfill unit and is regulated by the Federal CCR Rule.

### **2.4 Groundwater Monitoring Well Network**

The groundwater monitoring network for the Federal CCR Rule around Phase II was designed to comply with 40 CFR 257.91 (Geosyntec, 2017a). It includes four monitoring wells at the edge of waste (B15S, B16, B26, and B27) that were initially installed as part of a separate Site-wide hydrogeologic investigation and three additional monitoring wells (B37, B38, and B39) at the edge of waste that were installed explicitly for the Federal CCR Rule. It also utilizes a network of four background monitoring wells (B34, B35, B36, and B41) that were located and installed in consultation with Maryland Department of Environment (MDE) as part of a separate Site-wide hydrogeologic investigation. All of the Federal CCR Rule groundwater monitoring wells are screened in the upper aquifer (sand and gravel, when present) that is above the regional confining unit (Calvert Formation). Monitoring well construction and soil boring logs are provided in Geosyntec (2017a). Well locations are shown on **Figure 2**.

### **3. CONCEPTUAL SITE MODEL**

#### **3.1 Site Investigations**

Hydrogeologic investigations for CCR management at the Site began in the 1970s by a former owner/operator (GAI, 1975) and have continued to date. Geosyntec began hydrogeologic investigations at the Brandywine facility circa May 2011. At that time, a pre-existing groundwater monitoring system was in place that included six monitoring wells (B3 and B10-B14) that were installed by GAI (1989) as part of a previous facility investigation. There were also several potentiometric surface maps for the facility spanning 1994 through 2009 that indicate groundwater flow toward the northwest beneath the unlined Phase I area and to the southeast beneath the future Phase II area (William Porter, February 2003; 2009; see **Appendix A**). These reports characterized the Site as having very stable water levels that appeared to be controlled by pre-existing topography and did not appear to be affected by the placement of CCR in the Phase I area.

From 2012 through 2015, Geosyntec developed a preliminary Conceptual Site Model (CSM) using pre-existing Site information. The preliminary CSM was used to design the locations and depths of approximately 30 additional soil borings and groundwater monitoring wells to augment the pre-existing information and to expand well network for the entire site including the Phase II unit.

#### **3.2 Source**

The Site has an approximate design volume of 6.8 million (MM) cubic yards (yds<sup>3</sup>) of CCR. Phase I and Historical Areas 1 and 2 have been filled to their design capacities (approximately 5.3 million cubic yards) and had their vegetative soil covers replaced with vegetated geomembrane caps from 2015 through 2018. Currently Phase II (design volume approximately 1.5 million cubic yards) continues to receive CCR from the Chalk Point and Morgantown power generating stations. Prior to November 2007, CCR materials from the Potomac River generating station were also managed at the Site.

Under current operations at the Chalk Point generating station, brackish water from the Patuxent River is added to bottom ash to produce a slurry that is used to convey the bottom ash out of the boilers to hydrobins where the water is decanted prior to bottom ash being sent to the Brandywine Ash Management Facility (NRG, personal communication). Some naturally occurring constituents (i.e., chloride, TDS, boron, sulfate, etc.) from the brackish Patuxent River water may be retained in the residual moisture content of the CCRs that are placed in Phase II and may ultimately be mobilized into leachate after placement in the Phase II unit. These constituents are among the CCR Rule Appendix III indicator constituents monitored in groundwater around Phase II. CCRs in Historical Areas 1 and 2 and Phase I are mostly fly ash and are not known to have been slurried with brackish water from the Patuxent River (NRG, personal communication); therefore, leachate from Phase II might possess unique geochemical and/or isotopic signatures from the brackish Patuxent River slurry water that are dissimilar to the leachate signatures of Historical Areas 1 and 2 and Phase I.

### **3.3 Release Mechanisms**

As discussed in **Section 1.2**, from the mid-1970s through 2008 CCR was managed in the unlined Historical Areas and Phase 1. The primary release mechanism for CCR constituents from those areas to groundwater is via infiltration of precipitation, dissolution of the soluble components of the CCR material into leachate, and migration of leachate to groundwater.

Phase II is a modern lined CCR management cell with a geosynthetic bottom liner and leachate collection system. If a release from Phase II were to occur it would likely be from a point or linear defect in the liner. A release of that nature would likely be detected at only one or two perimeter monitoring wells. As discussed in **Section 4.2**, SSIs were detected above background concentrations at monitoring wells B16, B27, B37, B38, and B39 around the west, north, and east perimeter of Phase II. The spatial distribution of these SSIs does not suggest a narrow plume indicative of a release from a localized defect in the Phase II liner.

### **3.4 Migration Pathways**

The sand and gravel unit is the upper aquifer at the Site and is fluvial in origin. A regional aquitard (the Calvert Formation) underlies the sand and gravel and is comprised of marine silty clay. Regional groundwater flow in the upper aquifer in the Site vicinity is to the north/northeast toward the Matoponi Creek which is incised into the Calvert Formation confining unit and is therefore the discharge location for shallow groundwater above the Calvert Formation confining unit. Within the Site, groundwater flow directions are variable and are influenced by nearby tributaries to Matoponi Creek that are localized groundwater discharge zones. Potentiometric surface maps for the site are fairly consistent from season to season as illustrated for 2017 to 2018 on **Figures 3A through 3D**. Groundwater elevation data are summarized in **Table 1**.

Potentiometric surface maps for 1994 to 2009, provided as **Appendix A**, indicate a groundwater mound centered slightly northwest of the haul road under Phase I resulting in radial flow from Phase I toward the future location of Phase II. More recent potentiometric surface maps for the Site that are based on the past four quarterly monitoring events (second quarter 2017 through first quarter 2018), and include a greater number of observation wells than previously evaluated, are provided as **Figures 3A through 3D**. These recent potentiometric surface maps confirm the general flow patterns previously mapped, including the persistent groundwater mound along the haul road between Phase I and Phase II but show that it extends farther to the east beneath the western portion of Phase II.

The pre-development site features and topographic map presented as **Figure 4** shows that the northern half of Phase II was constructed over approximately 800 linear feet of nontidal intermittent stream and approximately 0.41 acres of nontidal wetlands. The stream originated at a spring near the eastern margin of Phase I. A slight slope toward the unnamed tributary to the east is shown on the pre-development topographic contours. The former intermittent stream and wetlands are within the footprint of Phase II, and span from the northwestern side of Phase II near the existing haul road and the truck wash to the northeastern side of Phase II near the head of Kevin's Creek. During construction of Phase II, a drainage pipe was installed in the foot print of

the former intermittent stream and wetlands to capture drainage from those areas and convey it to a discharge point at the headwaters of Kevin's Creek. This system might act as a preferential groundwater migration pathway from Phase I, beneath the northern portion of Phase II, and ultimately to the vicinity of Kevin's Creek east of Phase II. Monitoring well B39 is installed near this buried stream channel and potentially screened in the surrounding buried wetland soils.



#### **4. FEDERAL CCR RULE GROUNDWATER MONITORING**

Eight baseline monitoring program events (September 2015 through April 2017 at most wells) and one detection monitoring program event (October 2017) were completed at all background wells and compliance wells in accordance with the Sampling and Analysis Plan (SAP; Geosyntec, 2015a). The following section discusses the results of those monitoring events.

##### **4.1 Baseline and Detection Monitoring Programs**

Upper Prediction Limits (UPLs) of background concentrations were calculated for Appendix III constituents using the results of the Baseline Monitoring Program events at the background wells. The background concentrations were calculated using *ChemStat Version 6.3* following U.S. Environmental Protection Agency's (USEPA) groundwater monitoring statistical guidance (USEPA, 2009). The calculated background concentrations are provided in **Table 2**.

In October 2017, the first round of samples collected under the Detection Monitoring Program for Appendix III constituents was completed. The laboratory results were received on December 11, 2017, were presented in the annual monitoring report (Geosyntec, 2018), and are also presented in **Table 3**.

##### **4.2 Statistically Significant Increases**

The Detection Monitoring Program results were compared to calculated background concentrations on 11 March 2018 and SSIs above background concentrations were found for all Appendix III constituents except for fluoride. SSIs are highlighted on **Table 3**. SSIs above background were detected at five of the seven compliance monitoring wells (B16, B27, B37, B38, and B39).

The highest concentrations of Appendix III constituents were detected at monitoring well B16. It should be noted that the sulfate and TDS concentrations detected at well B16 were greater than those detected in the leachate samples collected from both Phase I and Phase II. Among the wells with SSIs, monitoring well B27 had the lowest concentrations of CCR constituents. Monitoring well B27 is located downgradient of Phase II to the east/southeast.

##### **4.3 January 2018 Alternate Source Demonstration Monitoring**

As discussed in **Section 2**, Phase I and Historical Areas 1 and 2 at the Site were inactive prior to the effective date of the CCR Rule and are therefore not subject to the regulation. However, these units are unlined and are likely a source of CCR constituents detected in groundwater samples at the Site (Geosyntec, 2015b). Therefore, in 2015 Geosyntec recommended installing monitoring wells B37 and B38 in the haul road between Phase I and Phase II to demonstrate that shallow groundwater would flow from Phase I toward the east, past wells B37 and B38, then beneath Phase II, and emerge to the east of Phase II at wells B27 and B39. At that time, it was envisioned that an alternate source demonstration would show flow from Phase I toward Phase II and higher concentration of constituents at wells B16, B37, and B38 than at wells B27 and B39. However, as

shown on **Figures 3A through 3D**, refinement of the potentiometric surface does not clearly indicate that wells B16, B37, and B38 are upgradient of Phase II.

Therefore, in the first quarter of 2018, Geosyntec collected leachate samples and additional groundwater samples for a geochemical forensics evaluation to support an alternate source demonstration at Phase II. The following water samples were collected:

- groundwater from monitoring wells screened beneath the ash in Phase I (B19, PZ22, and B22) that are representative of Phase I leachate;
- groundwater from monitoring wells that had SSIs around the perimeter of Phase II (B16, B27, B37, B38, and B39);
- groundwater from background monitoring well B34;
- Phase II leachate collected at the outfall pipe into Pond 006; and
- two quality control samples, including one field duplicate.

Groundwater samples were collected from existing groundwater monitoring wells using low-flow sampling protocol. Purging of the groundwater was performed at relatively low flow rates (between 0.1 and 0.5 liters per minute) in order to limit drawdown of the surrounding water table and limit stress on the formation. Water purged from the wells was monitored for the following water quality field parameters to document stabilization for sample collection: temperature, pH, specific conductivity, dissolved oxygen (DO), oxidation-reduction potential (ORP), and turbidity. Samples were collected when three consecutive readings indicated stability in the field parameters. Final field parameters collected after stabilization was reached are provided in **Table 4**. Once stabilization was reached, samples were collected for analysis of the following analytes by the analytical laboratories indicated:

- major solutes (total alkalinity, bicarbonate alkalinity, calcium, chloride, fluoride, magnesium, potassium, sodium, sulfate) by Eurofins Lancaster Laboratories Inc. (LLI) of Lancaster, Pennsylvania;
- stable isotopes of chloride and sulfur (in sulfate) by Isotope Tracer Technologies, Inc. (ITT) of Waterloo, Ontario;
- dissolved boron isotopes by Tetra Tech, Inc. (Tetra Tech) of Fort Collins, Colorado; and
- hydrogen and oxygen isotopes in water by the University of Arizona's Environmental Isotope Laboratory in Tempe, Arizona.

Unfiltered boron data from a first quarter 2018 monitoring event, performed under a separate program, and from the October 2017 samples at B37, B38 and B39, are also used in this analysis. All major ion analytical data were validated by Geosyntec's inhouse analytical chemist for a Stage 2A Validation according to EPA guidance "Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use" (EPA 540-R-08-005). All stable isotope analyses were performed in accordance with the laboratories' standard methods and quality control guidelines

and were considered complete and usable. The major solutes and isotope analytical data are presented in **Tables 5 and 6**, respectively. Note that the data for PZ22 are not shown on **Figure 7a** through **Figure 7c** because the results appear to be more similar to perimeter groundwater mixed with background groundwater than Phase I leachate. The stable isotope analyses for PZ22 shown on **Figure 8** and **Figure 9** confirm this interpretation.

## 5. ALTERNATE SOURCE DEMONSTRATION

### 5.1 Evaluation of Error

#### 5.1.1 *Potential Sampling Error*

Major solute results, as well as total suspended solids (TSS) and field turbidity measurements, were reviewed to identify potential outliers or potential sampling errors. All Appendix III constituents except calcium have a low potential for adsorption to suspended particulates in the samples and this was confirmed by the relatively small percent differences between the results for filtered and unfiltered sample results generated from a separate monitoring program. Therefore, the turbidity of the unfiltered samples has a low potential for causing false positive SSIs for Appendix III parameters other than calcium.

Field parameter measurements were consistent among the October 2017 Detection Monitoring Program samples, the preceding Baseline Monitoring Program samples, and the subsequent January 2018 ASD samples. Therefore, there is little potential for inconsistent purging/sampling technique to cause false positive SSIs in the October 2017 Detection Monitoring Program samples. Based on these evaluations, it was determined that sampling error likely did not contribute to the detected SSIs.

#### 5.1.2 *Potential Laboratory Analysis Error*

Geosyntec completed a Stage 2A data quality evaluation to assess whether laboratory analysis error might have occurred. All of the background data from the Baseline Monitoring Program as well as the data for the October 2017 and January 2018 compliance well samples were evaluated. In addition, the January 2018 data collected for this ASD were checked for cation vs. anion charge balance and the differences were outside normally acceptable limits (i.e. +/-20 percent relative percent difference) for some samples. Review of time series diagrams indicated that calcium data for several samples in the October 2017 and January 2018 samples were anomalous. Eurofins investigated the results for those samples, identified laboratory errors, and issued a corrected laboratory report. The corrected calcium data are reported in **Table 3** and **Table 5**.

#### 5.1.3 *Potential Statistical Analysis Error*

Geosyntec completed the background statistical calculations using the *ChemStat* commercial software package for groundwater monitoring statistics (Geosyntec, 2017b). The calculations underwent Geosyntec's standard peer review and senior review protocol prior to use on the project. Therefore, the potential for statistical analysis error is low.

### 5.2 Natural Variation

The Baseline Monitoring Program samples were collected over a period of two years and therefore should have captured the seasonal variation in groundwater quality. Most of the SSIs were well above the calculated background upper prediction limits (UPLs). Time series graphs show consistency in the data through time. Therefore, the likelihood of false positive SSIs due to natural

variation is low with one exception. Well B39 had a pH value of 2.9 and a field duplicate value of 3.0 whereas the lower end of the background two-sided prediction limit was 3.1. This slight exceedance of the lower limit is within measurement accuracy of the pH analysis and might also be due to natural variation. Natural variation could be related to the fact that B39 is the only compliance well installed through wetland soils. None of the background wells were installed through similar soils. The wetland soils might contain pyrite (iron sulfide) that could generate some sulfuric acid due to introduction of oxygen during well drilling operations and result in a lower pH compared to the background wells. Geosyntec has seen such conditions persist for several years in similarly situated monitoring wells at nearby sites.

### **5.3 Alternate Source**

As discussed in **Section 4.3** above, Geosyntec designed and implemented a chemical forensics investigation to evaluate whether the SSIs for Appendix III constituents detected in compliance wells during the October 2017 Detection Monitoring Program event might be due to an alternate source, and therefore not due to a release of Appendix III constituents from the Phase II unit.

Groundwater flow direction is equivocal for the southwest part of Phase II. Stiff diagrams, major ion ratios, and stable isotope analyses were each used as geochemical forensics tools to evaluate source-specific signatures among major solutes and isotopes from Phase I and Phase II. It was anticipated that the leachate samples from Phase II might exhibit source-specific major solute concentrations and stable isotope ratios that differ from those detected in Phase I groundwater samples and groundwater downgradient of Phase II.

The major solute data are presented in **Table 5** and the stable isotope data are presented in **Table 6**. These data facilitate development of forensics diagrams presented in **Figures 5A through 9** that could not be developed using the Appendix III data alone. A multiple lines of evidence approach was used in this evaluation including the presence/absence of SSIs for the primary indicators boron and sulfate, visualization of major solute composition using Stiff diagrams, Piper diagrams, and binary plots, as well as stable isotope mixing curves and binary plots.

#### *5.3.1 Primary Indicators*

Boron and sulfate are generally considered to be the primary (most reliable) indicators for coal ash leachate in most cases because they are present at high concentrations in CCR leachate relative to background groundwater, they are highly mobile in groundwater, and they generally are not attenuated (unless sulfate reducing conditions are encountered along a migration pathway). If SSIs are not detected for both of these primary indicators, the likelihood of a release from the CCR unit is low. The boron concentration in Phase II leachate was 53 mg/L and the sulfate concentration was 2,520 mg/L. The samples beneath Phase I ranged from 13.8 mg/L to 22.3 mg/L for boron and 2,100 mg/L to 3,740 mg/L for sulfate. The background UTLs are 0.025 mg/L and 18.6 mg/L, respectively. Therefore, both leachates have at least 2000 times higher concentrations of boron than background and 200 times higher sulfate concentrations such that releases of leachate to groundwater should be easily detected.

All compliance wells except for B15S and B26 had SSIs for both boron and sulfate indicating a release of CCR leachate to groundwater at the site is likely. However, it is possible that the boron and sulfate could have been released from Phase I and not from Phase II. Therefore, other lines of evidence were also evaluated.

### 5.3.2 Stiff Diagrams

Stiff diagrams are a tool to visualize the major solute composition of a water. Stiff diagrams were prepared for background monitoring well B34; compliance monitoring wells B16, B27, B37, B38, and B39; Phase I leachate (B19, B22, and PZ22); and Phase II leachate (Pond 006) using the major solute results provided in **Table 5**. Each polygon represents one sample but they can be stacked adjacent to each other to allow for comparison of the diagram shapes. Stiff diagrams with similar shapes might have derived their solutes from a common or similar source. Laboratory data, that are normally reported in mg/L, are converted to milliequivalents per liter (meq/L) for visualization. They show cations on the left half of the diagram and anions on the right half of the diagram. There should be equal areas within the polygon on each side of the central (vertical) axis of the diagram so that the total charges of cations and anions are balanced and the water sample is electrically neutral. This is a useful quality control check on the laboratory data. The overall size of the polygon is proportional to the total dissolved solids content of the sample.

Stiff Diagrams for the January 2018 samples are presented on **Figure 5A**. Leachate samples are shown in red at the bottom of the diagram and groundwater samples from the compliance wells are shown in green. The diagram for the background well B34 is given at the top of **Figure 5A** but the concentrations are too low to generate a visible polygon at the scale of this figure.

The diagram for the January 2018 Phase II leachate sample at the bottom of **Figure 5A** shows that sodium is the dominant cation and the anions are comprised of roughly equal amounts of sulfate and chloride, with no bicarbonate. Therefore, the Phase II leachate sample is referred to as a ‘sodium-mixed anion type water’. It has relatively lower amounts of calcium and magnesium compared to sodium. This diagram is the source ‘fingerprint’ for major solutes in Phase II leachate.

The diagrams for the January 2018 Phase I leachate samples (B19, B22, and PZ22) also at the bottom of **Figure 5A** show that no single cation is dominant and that sulfate is the dominant anion in those samples, with lesser amounts of chloride and little or no bicarbonate. Therefore, the Phase I leachate samples are referred to as a ‘mixed cation-sulfate type water’. This diagram is the source ‘fingerprint’ for major solutes in Phase I leachate. Note that the relative proportion of sulfate to chloride is much greater in the Phase I leachate compared to the Phase II leachate. The additional chloride in the Phase II sample might be related to residual brackish Patuxent River water transported to the site with the ash and the relative proportion of sulfate to chloride is a useful fingerprint to distinguish potential leachate releases from Phase I vs. Phase II.

The diagrams for the Phase II compliance well samples are shown in green on **Figure 5A**. The shapes for B37, B38 and B39 are somewhat similar to those for Phase I leachate but have more calcium. The relative proportions of sulfate to chloride are more similar to Phase I leachate than Phase II leachate. These stiff diagrams indicate there is a roughly equal mixture of cations, but the

anions are dominated by sulfate, with chloride as the next most dominant anion. The sulfate to chloride proportions indicate that the solutes detected in these three compliance wells could be derived from Phase I leachate and are unlikely to be derived from Phase II leachate.

The shapes for wells B16 and B27 are unique and different from the other three compliance wells. The sample from well B16 is a 'sodium-sulfate type water'. It has a much greater proportion of sodium and sulfate relative to the other compliance wells. It also has a much higher concentration of sodium and sulfate than either of the leachate samples. Presumably the highest concentrations of Appendix III constituents would be detected in the leachate. Therefore, Phase II leachate cannot be the sole source of the sodium and sulfate concentrations observed at B16. The higher proportion of sulfate relative to chloride also indicates that the solutes in B16 are not derived from a release of Phase II leachate.

The sample from B27 has much lower concentrations of all major cations and anions. The Stiff diagrams for monitoring wells B27 and B37 do not resemble either Phase I or Phase II leachate Stiff diagrams. The cations in the Stiff diagram for B27 is dominated by calcium, which is not observed in any of the other Stiff diagrams. The pattern of B27 does not match either of the leachates (nor B16) and might indicate that the solutes detected at B27 are from a source other than the two leachates and different from the additional potential source at B16.

**Figures 5B through 5F** show that there is not much seasonal variation in the shape of the Stiff diagrams and therefore the interpretation of results for the January 2018 samples can be extrapolated to other monitoring events including the October 2017 Detection Monitoring Program event that had SSIs.

### 5.3.3 Piper Diagram

A Piper Diagram for the January 2018 samples of leachate and groundwater is presented in **Figure 6**. Piper diagrams are another tool to visualize the major solute composition and it allows plotting multiple water samples together on one diagram to evaluate whether:

- They might have a common source of major solutes; and
- Some of the samples might be derived by mixing between other samples on the diagram.

The diagram has three components and uses units of meq/L. The large diamond-shaped component displays the combined cation and anion composition of major solutes. The two smaller triangular components display the cation components and the anion components separately and in greater detail. The sample data are plotted as a percentage of the totals on the diagram with each component reaching 100 percent at its respective corner of the diagram. In this manner they show the relative abundance of major cations and anions relative to each other, but not the magnitude of the concentrations.

The open circle point for Phase II leachate does not plot in the same portion of the diagram as the other points indicating that the other wells do not derive their solutes due to a release of Phase II leachate. In fact, the points for Phase II compliance wells B37, B38, and B39, as well as background well B34, generally plot in the same portion of the diagram as the Phase I leachate

samples (B19, B22, and PZ22). Phase II leachate has a greater proportion of sodium and chloride compared to Phase I leachate and compared to these three Phase II compliance wells, as was discussed above for the Stiff diagrams.

Phase II compliance wells B16 and B27 each plot in a unique portion of the Piper diagram. This indicates that they derive much of their solutes from a source different than both Phase I and Phase II leachate. B16 has a much greater proportion of sodium compared to the other wells and B27 has a much greater proportion of magnesium and bicarbonate. These findings are also consistent with those for the Stiff diagrams described above.

#### 5.3.4 Major Solute Binary Plots

Binary plots are a third way to visualize the data collected for Appendix III constituents. They also allow evaluation of mixing of various waters. Binary plots are provided in **Figure 7A** through **Figure 7C** for three highly mobile constituent pairs, including boron vs. sulfate, sulfate vs. chloride, and boron vs. chloride. These constituents do not adsorb to aquifer solids and hence should maintain their relative concentrations from leachate if released into shallow groundwater. Based on the plots, it is evident that data points for the various monitoring events at each monitoring well form their own cluster, indicating concentrations of these constituents did not vary significantly over the monitoring period, consistent with the findings of the Stiff diagrams in **Figures 5B through 5F** above.

The binary plot of boron vs. sulfate indicates, in a qualitative way, that by mixing Phase I leachate with water from background wells B34 in varying proportions, waters that have similar sulfate and boron composition to B27, B37, B38, and B39 can be produced. None of those wells plots on the hypothetical mixing line between background well B34 and Phase II leachate. **Figure 7A** provides very strong evidence that the solutes detected in samples from B27, B37, B38, and B39 are not due to a release of Phase II leachate and are more likely derived from Phase I leachate. B16 plots in a unique part of the diagram with higher concentrations than any other sample. This finding is likely due to a source other than the two leachates. Similarly, the binary plot of sulfate vs. chloride on **Figure 7B** leads to the same conclusions. The binary plot for chloride vs. boron on **Figure 7C** is less conclusive.

#### 5.3.5 Boron Isotope Mixing Diagrams

Stable isotope analysis of solutes is a powerful tool for fingerprinting a solute's potential source(s). Boron has two stable isotopes: boron-10 and boron-11. Both isotopes have similar chemical behavior but the ratio in a sample media can be changed during certain chemical and physical reactions. Therefore, the stable isotope composition of CCR leachate can be different from that in background groundwater and serve as a 'fingerprint tracer' for CCR leachate. Isotope analyses measure the ratio of the two isotopes and express them relative to the ratio in a standard. The result is expressed as the difference of the ratio in the sample and the standard in parts per thousand (per mil, o/oo).

The results of boron isotope analyses are given in **Table 6** and plotted on a boron mixing diagram for those samples on **Figure 8**. The diagram plots the sample's boron concentration on the x-axis



vs. its stable boron isotope composition on the y-axis. The diagram also includes a mixing line connecting calculated values for hypothetical mixtures of two end members, Phase II leachate and background groundwater, in varying proportions. It is clear from **Figure 8** that the boron detected in the compliance wells is not derived from Phase II leachate and more closely resembles Phase I leachate. The background boron isotopic composition is very heavy relative to the other samples, but has a very low concentration. The Phase II leachate sample (Pond 006) is the most isotopically light of the samples. Even a small amount of leachate in a groundwater sample will result in an isotopic composition very similar to the leachate because the leachates have a much greater boron concentration relative to background groundwater. This is shown by the rapid drop of the boron isotope value along the mixing line in **Figure 8**. Phase I leachate and the compliance wells have intermediate boron isotopic compositions. The boron isotope data provide another very strong line of evidence that the boron SSIs are not due to a release of Appendix III constituents to groundwater from Phase II leachate.

### 5.3.6 Deuterium and Oxygen Isotopes

**Figure 9** shows the isotopic composition of the water itself (i.e. the solvent, not the solutes) at the various sample locations. Stable isotope analysis for oxygen measures the ratio of oxygen-18 to oxygen-16 and stable isotope analysis for hydrogen measures the ratio of deuterium (hydrogen-2) to hydrogen-1. The results are shown on **Figure 9** and in **Table 6**. The oxygen-18 content of Phase II leachate is greater (i.e. ‘heavier’) than that for all the other samples, including Phase I leachate. The background groundwater is the most isotopically light. Mixing of leachate with background water would plot along a straight mixing line connecting the leachate and background points as shown on **Figure 9**. The relative distance along the line is proportional to the relative volumes of each end member in the mixture. Therefore, B27 has relatively little potential leachate water in the sample, and B37 has less than B38 and B39, as expected based on the concentrations of dissolved solutes in samples from these wells. PZ22, B37, B38, and B39 appear to have roughly equal proportions of background groundwater mixed with Phase I leachate. These wells do not plot on the mixing line between background and the Phase II leachate sample. Therefore, the isotopic composition of these waters provide a strong line of evidence that the SSIs detected at the Phase II compliance wells are not due to a release of leachate from Phase II and are more likely related to Phase I leachate.

The sample from B16 is again unique compared to the other wells. On **Figure 9** it appears that B16 might be due to mixing of Phase I and Phase II leachate. However, the solute concentrations are greater in B16 than in either leachate. Therefore, the isotopic composition of water at B16 cannot be derived by mixing the two leachates. It might be due to infiltration of potable water used at the on-site tire wash station, which is located near monitoring well B16. The tire wash water is pumped from a deep well screened below the Calvert Formation confining unit. Water obtained from that deeper aquifer is expected to contain more oxygen-18 relative to shallow groundwater because it has had more time to exchange isotopes with the aquifer solids that contain more of the heavier isotopes (Barnes, 1979).

### 5.3.7 *Sulfur and Chlorine Stable Isotopes*

The analytical results for stable isotopes of sulfur (in sulfate) and chlorine (in chloride) are given in **Table 6** and are less conclusive than the results for the other stable isotopes. The sulfate concentration in the background sample from well B34 was too low and resulted in no useable result for a sulfur isotope mixing diagram. Nevertheless, the sulfur in Phase II leachate contains more sulfur-34 (i.e. 'heavier') compared to all the other samples except B39. The other compliance well samples were more similar to the sulfur-34 content of Phase I leachate.

The stable chlorine isotope ratios of Phase I and Phase II leachates are similar and therefore were not useful tools for this site.

## **6. CONCLUSIONS AND RECOMMENDATIONS**

This ASD was prepared in accordance with 40 CFR 257.94(e)(2). The following lines of evidence indicate that the SSI of Appendix III constituents in October 2017 Detection Monitoring Program samples are not due to a leachate release from the regulated Phase II CCR unit.

1. The CCR unit is a dry ash management landfill cell that was built in 2008 in accordance with updated State design regulations and documented by a construction quality assurance program (GAI, 2008). Therefore, the likelihood of a release from the unit is low. The leachate collection system and the low permeability clay/geomembrane liner should limit the potential for leachate releases. If a release did occur, it would likely be through either a point or linear defect in the geomembrane and result in an SSI in only one or two compliance wells. However, SSIs were detected at most compliance wells.
2. The Stiff diagrams for compliance wells B37, B38, and B39 have relative proportions of sulfate to chloride that is more similar to Phase I leachate than Phase II leachate.
3. The Stiff diagram for compliance well B16 also has a higher proportion of sulfate to chloride than Phase II leachate. It also has much greater proportion of sodium and sulfate relative to the other compliance wells, and the concentrations of sodium and sulfate are higher than either of the leachate samples. Therefore, some of the sodium and sulfate detected in B16 samples is derived from a source other than the two leachates. The higher proportion of sulfate relative to chloride indicates that the solutes in B16 are not derived from a release of Phase II leachate.
4. The Stiff diagram for compliance well B27 does not match either of the leachates (nor B16) and might indicate that the solutes detected at B27 are from a source other than the two leachates and different from the additional potential source at B16.
5. Binary plots of Appendix III constituents indicate that the major solute compositions detected in the compliance wells cannot be derived from mixing of background groundwater with Phase II leachate and are more likely due to mixing of background groundwater with Phase I leachate that subsequently migrates beneath the Phase II unit.
6. Mixing curves for stable isotopes of boron indicate that the boron concentrations and isotope ratios in the downgradient compliance wells cannot be attributed to a leachate release from Phase II.
7. The isotopic composition of the water itself indicates that the compliance wells contain Phase I leachate and not Phase II leachate.

Multiple lines of evidence indicate that the SSIs for Appendix III constituents in the downgradient compliance wells are not due to a release from the CCR unit. Therefore, the CCR unit may remain in the Detection Monitoring Program and does not need to establish an Assessment Monitoring Program.

## 7. CERTIFICATION

I, William M. Steier, a qualified professional engineer registered in the state of Maryland, verify the accuracy of the information in the *Alternate Source Demonstration Report for the Brandywine Ash Management Facility Phase II Unit* based on my review and understanding of the requirements of 40 CFR 257.94(e)(2).

PE Name: William M. Steier  
PE License Number: 26728 State: Maryland

Signature: 

Date: 16 July 2018



Stamp:

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# TABLES

**TABLE 1  
GROUNDWATER ELEVATIONS**

**Alternate Source Demonstration  
Brandywine, Maryland**

Well ID	Top of Casing Elevation (ft msl)	Depth to Water (ft btoic)	Groundwater Elevation (ft msl)	Depth to Water Measurement Date		
B12	201.84	7.68	194.16	8/21/2015		
		5.96	195.88	11/9/2015		
		5.86	195.98	1/21/2016		
		6.00	195.84	4/12/2016		
		7.05	194.79	7/18/2016		
		6.92	194.92	10/4/2016		
		4.96	196.88	1/25/2017		
		5.59	196.25	4/5/2017		
		7.50	194.34	7/25/2017		
		10.89	190.95	10/23/2017		
		6.53	195.31	1/29/2018		
		B13	178.83	5.02	173.81	8/21/2015
5.28	173.55			11/9/2015		
3.53	175.30			1/21/2016		
3.40	175.43			4/12/2016		
3.99	174.84			7/18/2016		
3.49	175.34			10/4/2016		
3.37	175.46			1/25/2017		
3.46	175.37			4/5/2017		
4.60	174.23			7/25/2017		
3.78	175.05			10/24/2017		
3.35	175.48			1/29/2018		
B14	193.15			8.21	184.94	8/21/2015
		7.61	185.54	11/9/2015		
		6.33	186.82	1/21/2016		
		5.74	187.41	4/12/2016		
		7.31	185.84	7/18/2016		
		8.52	184.63	10/4/2016		
		8.02	185.13	1/25/2017		
		7.50	185.65	4/5/2017		
		9.15	184.00	7/25/2017		
		9.18	183.97	10/24/2017		
		8.72	184.43	1/29/2018		
		B15S	214.95	12.61	202.34	8/21/2015
13.33	201.62			11/9/2015		
10.61	204.34			1/21/2016		
9.24	205.71			4/12/2016		
10.95	204.00			7/18/2016		
13.50	201.45			10/4/2016		
11.83	203.12			1/25/2017		
11.08	203.87			4/5/2017		
12.95	202.00			7/25/2017		
13.08	210.87			10/23/2017		
14.14	200.81			1/29/2018		
B16	236.11			28.75	207.36	8/21/2015
		29.08	207.03	11/9/2015		
		28.98	207.13	1/21/2016		
		28.61	207.50	4/12/2016		
		28.79	207.32	7/18/2016		
		29.04	207.07	10/4/2016		
		29.01	207.10	1/25/2017		
		28.78	207.33	4/5/2017		
		27.80	208.31	7/25/2017		
		29.27	206.83	10/23/2017		
		29.54	206.57	1/10/2018		
		29.55	206.56	1/29/2018		
B17S	220.13	16.02	204.11	8/21/2015		
		16.81	203.32	11/9/2015		
		15.33	204.80	1/21/2016		
		14.41	205.72	4/12/2016		
		15.46	204.67	7/18/2016		
		16.64	203.49	10/4/2016		
		16.12	204.01	1/25/2017		
		15.44	204.69	4/5/2017		
		16.50	203.63	7/25/2017		
		17.34	202.79	1/29/2018		
B19	246.00	54.34	191.66	8/21/2015		
		55.12	190.88	11/9/2015		
		55.89	190.11	1/21/2016		
		56.40	189.60	4/12/2016		
		55.21	190.79	7/18/2016		
		55.20	190.80	10/4/2016		
		NM	[2]	1/25/2017		
		NM	[2]	4/5/2017		
		62.37	183.63	7/25/2017		
		63.19	182.81	1/10/2018		
		NM	[2]	1/29/2018		
		B22	281.95	77.62	204.33	8/21/2015
77.97	203.98			11/9/2015		
78.19	203.76			1/21/2016		
77.86	204.09			4/12/2016		
77.95	204.00			7/18/2016		
78.00	203.95			10/4/2016		
289.30	72.22		209.73	1/25/2017		
	78.09		203.86	4/5/2017		
	78.85		203.10	7/25/2017		
	86.48		202.82	1/10/2018		
	85.56		203.74	1/29/2018		
	B24S		199.47	15.02	184.45	8/21/2015
15.44		184.03		11/9/2015		
14.81		184.66		1/21/2016		
14.50		184.97		4/12/2016		
14.47		185.00		7/18/2016		
14.05		185.42		10/4/2016		
14.81		184.66		1/25/2017		
14.94		184.53		4/5/2017		
15.50		183.97		7/25/2017		
16.02		183.45		1/29/2018		
B25		206.35		24.23	182.12	8/21/2015
				23.94	182.41	11/9/2015
	23.70		182.65	1/21/2016		
	23.85		182.50	4/12/2016		
	23.94		182.41	7/18/2016		
	23.59		182.76	10/4/2016		
	23.69		182.66	1/25/2017		
	22.21		184.14	4/5/2017		
	24.40		181.95	7/25/2017		
	23.61		182.74	1/29/2018		
	B26		218.41	14.01	204.40	10/23/2015
				14.22	204.19	11/9/2015
13.41		205.00		1/21/2016		
13.12		205.29		4/12/2016		
13.27		205.14		7/18/2016		
13.72		204.69		10/4/2016		
13.84		204.57		1/25/2017		
13.29		205.12		4/5/2017		
14.02		204.39		7/25/2017		
15.46		202.92		10/23/2017		
14.14		204.27		1/29/2018		
B27		214.77		20.57	194.20	8/21/2015
	21.45		193.32	11/9/2015		
	19.60		195.17	1/21/2016		
	19.50		195.27	4/12/2016		
	20.33		194.44	7/18/2016		
	21.50		193.27	10/4/2016		
	20.86		193.91	1/25/2017		
	19.86		194.91	4/5/2017		
	21.30		193.47	7/25/2017		
	21.54		163.23	10/23/2017		
	21.93		192.84	1/11/2018		
	21.87		192.90	1/29/2018		



**TABLE 1  
GROUNDWATER ELEVATIONS**

**Alternate Source Demonstration  
Brandywine, Maryland**

Well ID	Top of Casing Elevation [1] (ft msl)	Depth to Water (ft btoic)	Groundwater Elevation (ft msl)	Depth to Water Measurement Date
B28	179.78	9.61	170.17	8/21/2015
		8.20	171.58	11/9/2015
		6.49	173.29	1/21/2016
		5.89	173.89	4/12/2016
		7.41	172.37	7/18/2016
		7.10	172.68	10/4/2016
		6.40	173.38	1/25/2017
		6.21	173.57	4/5/2017
		9.97	169.81	7/26/2017
		8.21	171.57	1/29/2018
B29	230.48	25.43	205.05	8/21/2015
		26.52	203.96	11/9/2015
		26.63	203.85	1/21/2016
		24.64	205.84	4/12/2016
		25.01	205.47	7/18/2016
		26.25	204.23	10/4/2016
		27.81	202.67	1/25/2017
		26.88	203.60	4/5/2017
		26.55	203.93	7/25/2017
		32.32	198.16	1/29/2018
B31	212.05	42.14	169.91	8/21/2015
		42.69	169.36	11/9/2015
		42.62	169.43	1/21/2016
		41.89	170.16	4/12/2016
		41.77	170.28	7/18/2016
		42.09	169.96	10/4/2016
		42.53	169.52	1/25/2017
		43.60	168.45	4/5/2017
		43.12	168.93	7/25/2017
		42.45	169.60	1/29/2018
B34	215.34	15.26	200.08	8/21/2015
		16.31	199.03	11/9/2015
		15.27	200.07	1/21/2016
		14.49	200.85	4/12/2016
		15.08	200.26	7/18/2016
		16.27	199.07	10/4/2016
		16.19	199.15	1/25/2017
		15.91	199.43	3/1/2017
		15.44	199.90	4/5/2017
		15.35	199.99	5/12/2017
		15.32	200.02	6/13/2017
		16.40	198.94	7/25/2017
		15.78	199.56	8/28/2017
		16.61	198.73	10/23/2017
		17.17	198.17	1/11/2018
17.31	198.03	1/29/2018		
B35	206.82	7.89	198.93	8/21/2015
		8.05	198.77	11/9/2015
		4.50	202.32	1/21/2016
		6.05	200.77	4/12/2016
		6.86	199.96	7/18/2016
		5.30	201.52	10/4/2016
		3.81	203.01	1/25/2017
		5.86	200.96	2/28/2017
		4.25	202.57	4/5/2017
		3.81	203.01	5/12/2017
		6.30	200.52	6/13/2017
		8.40	198.42	7/25/2017
		5.33	201.49	8/28/2017
		7.72	199.10	10/23/2017
		7.97	198.85	1/29/2018

Well ID	Top of Casing [1] Elevation (ft msl)	Depth to Water (ft btoic)	Groundwater Elevation (ft msl)	Depth to Water Measurement Date
B36	206.68	18.12	188.56	8/21/2015
		19.31	187.37	11/9/2015
		18.93	187.75	1/21/2016
		17.60	189.08	4/12/2016
		18.21	188.47	7/18/2016
		19.17	187.51	10/4/2016
		19.97	186.71	1/25/2017
		19.53	187.15	2/28/2017
		19.29	187.39	4/5/2017
		19.65	187.17	5/12/2017
		18.46	188.22	6/13/2017
		19.71	186.97	7/25/2017
		19.29	187.39	8/28/2017
		19.14	187.54	10/23/2017
		20.45	186.23	1/29/2018
B38	233.27	26.03	207.24	8/21/2015
		26.13	207.14	11/9/2015
		26.02	207.25	1/21/2016
		25.54	207.73	4/12/2016
		25.59	207.68	7/18/2016
	233.66	26.08	207.19	10/4/2016
		26.13	207.14	1/25/2017
		26.02	207.25	4/5/2017
		29.70	203.57	7/25/2017
		26.20	207.07	10/23/2017
B39	202.71	26.69	206.97	1/11/2018
		26.64	207.02	1/29/2018
		12.13	190.58	8/21/2015
		10.73	191.98	11/9/2015
		10.31	192.40	1/21/2016
		10.66	192.05	4/12/2016
		11.40	191.31	7/18/2016
		10.60	192.11	10/4/2016
		10.98	191.73	1/25/2017
		10.48	192.23	4/5/2017
		12.70	190.01	7/25/2017
		10.43	192.28	10/23/2017
		11.48	191.23	1/10/2018
		NM	[2]	1/29/2018
		B40 [4]	202.5	23.59
25.25	177.25			11/7/2016
23.50	179.00			12/7/2016
23.61	178.89			1/25/2017
23.55	178.95			2/28/2017
23.39	179.11			4/5/2017
23.32	179.18			5/12/2017
23.32	179.18			6/13/2017
23.89	178.61			7/25/2017
23.46	179.04			8/28/2017
B41 [4]	211.5	23.77	178.73	10/23/2017
		24.30	178.20	1/29/2018
		26.89	184.61	10/12/2016
		28.40	183.10	11/7/2016
		27.50	184.00	12/7/2016
		28.01	183.49	1/25/2017
		28.19	183.31	2/28/2017
		27.75	183.75	4/5/2017
		26.99	184.51	5/12/2017
		26.39	185.11	6/13/2017
		27.07	184.43	7/26/2017
		27.05	184.45	8/28/2017
		27.54	183.96	10/23/2017
		28.64	182.86	1/29/2018

**TABLE 1  
GROUNDWATER ELEVATIONS**

**Alternate Source Demonstration  
Brandywine, Maryland**

Well ID	Top of Casing Elevation [1] (ft msl)	Depth to Water (ft btoic)	Groundwater Elevation (ft msl)	Depth to Water Measurement Date
B37	220.00 [1]	12.21	207.79	8/21/2015
		12.92	207.08	11/9/2015
		13.20	206.80	1/21/2016
		13.34	206.66	4/12/2016
		12.07	207.93	7/18/2016
		12.85	207.15	10/4/2016
		12.70	207.30	1/25/2017
		12.42	207.58	4/5/2017
		12.80	207.20	7/25/2017
		12.74	207.26	10/23/2017
	220.23	13.10	207.13	1/11/2018
		13.43	206.80	1/29/2018
PZ22	281.54	79.11	202.43	8/21/2015
		78.94	202.60	11/9/2015
		79.24	202.30	1/21/2016
		79.19	202.35	4/12/2016
		79.19	202.35	7/18/2016
		79.07	202.47	10/4/2016
		79.15	202.39	1/25/2017
		79.19	202.35	4/5/2017
		79.94	201.60	7/25/2017
		79.80	201.74	1/15/2018
		79.75	201.79	1/29/2018

Notes:

- ft bgs feet below ground surface
- ft msl feet above mean sea level
- ft btoic feet below top of inner case
- NM Not measured

[1] Top of casing elevation is an estimated value based on ground elevation prior to 2018 at B37 and B38 and casing elevation changed in 2018 at B22.  
 [2] No groundwater elevation data provided due to inaccessibility of monitoring well at time of measurement.

**TABLE 2  
BACKGROUND CONCENTRATIONS FOR APPENDIX III CONSTITUENTS**

**Alternate Source Demonstration  
Brandywine Ash Management Facility,  
Phase II  
Brandywine, Maryland**

<b>Appendix III Parameter</b>	<b>Unit</b>	<b>UPL [1]</b>
Boron	µg/L	25
Calcium	mg/L	6.32
Chloride	mg/L	14.1 [2]
Fluoride	mg/L	[3]
pH	S.U.	3.1-7.7
Sulfate	mg/L	18.6
Total Dissolved Solids	mg/L	239

Notes:

UPL Upper Prediction Limit  
 µg/L micrograms per Liter  
 mg/L milligrams per Liter  
 S.U. Standard Units

[1] Subject to change as additional data are generated. Calculations provided in Statistical Analysis Calculations Package for Background Groundwater – Phase II, Brandywine Ash Storage Facility, Brandywine, MD (Geosyntec, 2017).

[2] The background dataset has a lognormal distribution but does not display equal variance; thus, were calculated using nonparametric methods (Unified Guidance, 2009).

[3] The Double Quantification Rule (DQR) is used for background data sets with no detections.

Source: Federal CCR Rule - 2017 Annual Groundwater and Corrective Action Report (Geosyntec, 2018).

**TABLE 3  
STATISTICALLY SIGNIFICANT INCREASES ABOVE BACKGROUND**

**Alternate Source Demonstration  
Brandywine Ash Management Facility, Phase II  
Brandywine, Maryland**

Analyte:		Boron	Calcium	Chloride	Fluoride	pH	Sulfate	TDS
Background:		25	6.32	14.1	<0.25 U	3.1 - 7.7	18.6	239
Well ID	Sample Date	µg/L	mg/L	mg/L	mg/L	S.U.	mg/L	mg/L
B15S	10/24/2017	13.6 J	1.93	3.9	<0.25 U	5.0	13.3	39.5
B16	10/25/2017	49,500	377	1,580	<0.25 U	6.8	6,410	11,000
B26	10/25/2017	17.0 J	4.08	8.8	<0.25 U	4.3	13.2	53.0
B27	10/25/2017	632	42.7	56.0	<0.25 U	5.9	153	519
B37	10/24/2017	2,050	104	157	1.0	4.3	624	1,120
B38	10/24/2017	14,900	360	203	0.45 J	6.3	2,530	3,580
B39	10/25/2017	4,870	69.4	426	0.51 J+	2.9 J	1,500	2,200
B39 [1]	10/25/2017	4,850	69.2	402	<0.25	3.0 J	1,310	2,120

Notes:

Concentration is a statistically significant increase (SSI) over background concentration. Fluoride follows the Double Quantification Rule and two consecutive fluoride detections have not been recorded.

µg/L micrograms per Liter

mg/L milligrams per Liter

S.U. Standard Units

J Constituent detected below reporting (quantitation) limit; result is an estimated value.

J+ Constituent detected below reporting (quantitation) limit; result is an estimated value with a high bias.

U Constituent not detected above method detection limit.

NS Not Sampled

[1] Duplicate sample collected.

Source: Federal CCR Rule - 2017 Annual Groundwater and Corrective Action Report (Geosyntec, 2018).

**TABLE 4  
FIELD PARAMETERS**

**Alternate Source Demonstration  
Brandywine Ash Management Facility, Phase II  
Brandywine, Maryland**

Well ID	Sample Date	Parameter					
		Temperature (°C)	pH (S.U.)	Dissolved Oxygen (mg/L)	Specific Conductance (µS/cm)	Oxidation Reduction Potential (mV)	Turbidity (NTU)
B16	1/10/2018	17.27	5.98	1.10	14,930	122.0	7.83
B19	1/10/2018	13.73	6.49	1.51	6,844	-69.0	949.00
B22	1/10/2018	17.03	4.13	0.62	8,810	103.1	4.52
B27	1/11/2018	14.41	6.21	0.70	792 [3]	177.6	50.6
B34	1/11/2018	14.00	4.92	4.88	48 [3]	243.5	3.46
B37	1/11/2018	16.85	5.10	0.36	1,085	236.3	2.46
B38	1/11/2018	16.63	5.73	0.20	4,463	78.0	3.21
B39	1/10/2018	13.91	3.32	0.86	3,163	339.0	6.91
Pond 006	1/15/2018	14.25	7.22	3.11 [1]	9,340	-57.4 [1]	2.53
PZ22	1/15/2018	9.99	5.83	4.92	5,021	59.3	>1,000 [2]

Notes:

- °C degrees Celsius
- S.U. Standard Units
- mg/L milligrams per Liter
- OOOR Out of Range
- µS/cm microSiemens per centimeter
- mV millivolts
- NTU Nephelometric Turbidity Unit

- [1] Dissolved oxygen concentration and negative oxidation reduction potential values are inconsistent.
- [2] The value is greater than the upper range of the instrument.
- [3] Specific conductivity value is lower than expected based on sum of major constituents in Table 5.

**TABLE 5  
ANALYTICAL RESULTS - MAJOR SOLUTES**

**Alternate Source Demonstration  
Brandywine Ash Management Facility, Phase II  
Brandywine, Maryland**

Analyte:		Alkalinity (Bicarbonate as CaCO <sub>3</sub> )	Alkalinity (Total) as CaCO <sub>3</sub>	Boron	Calcium	Chloride	Fluoride	Magnesium	Potassium	Sodium	Sulfate
Well ID	Sample Date [1]	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
B16	1/10/2018	487	487	53.2	387	1,640	<0.25U	139	164	3,500	5,980
B19	1/10/2018	693	693	22.3	552	845	0.44J	258	257	680	2,570
B22	1/10/2018	<1.70U	<1.70U	13.8	393	1,230	1.8	326	315	879	3,740
B27	1/11/2018	256	256	0.624	35.3	78.5	<0.25U	56.4	13.9	42.8	158
B34	1/11/2018	<1.70U	<1.70U	0.0097	0.7	4.00	<0.25U	1.30	0.646	3.22	5.1
B37	1/11/2018	<1.70U	<1.70U	2.05	86.4	150	0.97	30.3	5.67	82.7	399
B38	1/11/2018	54.1	54.1	14.9	342	257	<0.25U	156	242	234	2,440
B39	1/10/2018	<1.70U	<1.70U	4.87	82.7	394	<0.25U	83.2	3.38	238	1,910
B39 [2]	1/10/2018	<1.70U	<1.70U	4.85	83.0	459	0.73	82.0	3.51	234	2,190
Pond 006	1/15/2018	240	240	53	622	1,750	<0.25U	95.7	223	1,300	2,520
PZ22	1/15/2018	73.2	73.2	NS	304	609	1.0	181	112	461	2,100

Notes:

mg/L milligrams per Liter

S.U. Standard Units

J Constituent detected below reporting (quantitation) limit; result is an estimated value.

U Constituent not detected above method detection limit.

NS Not sampled.

[1] Boron samples for B37, B38, and B39 collected on October 24, 2017, all other boron samples collected on Jan 31 and Feb 2, 2018.

[2] Duplicate sample collected.

**TABLE 6**  
**ANALYTICAL RESULTS - STABLE ISOTOPES**

**Alternate Source Demonstration**  
**Brandywine Ash Management Facility, Phase II**  
**Brandywine, Maryland**

Analyte:		$\delta^{37}\text{Cl}$	$\delta^{34}\text{S}$	B (mg/L)	$\delta^{11}\text{B}$ ‰	$\delta^{18}\text{O}$ ‰	$\delta\text{D}$ ‰
Well ID	Sample Date	[1]	[2]		[3]	[4]	[4]
B16	1/10/2018	-0.12	8.2	54.0	-2.6	-6.1	-38.0
B19	1/10/2018	-0.03	7.4	22.3	10.5	-6.4	-37.3
B22	1/10/2018	0.18	3.6	13.8	5.5	-6.3	-38.5
B27	1/11/2018	-0.07	5.9*	0.65	11.9	-7.7	-45.8
B34	1/11/2018	-0.20	BDL	0.0101	39.9	-7.8	-47.7
B37	1/11/2018	0.17	3.1	2.05	18.2	-7.0	-41.8
B38	1/11/2018	-0.26	4.6	14.9	2.3	-6.9	-41.0
B39	1/10/2018	-0.21	9.9	4.87	27.8	-6.8	-41.2
B39 [5]	1/10/2018	-0.08	10.2	4.85	28.4	-6.8	-40.8
Pond 006	1/15/2018	0.02	9.8	51	-10.8	-6.0	-38.9
PZ22	1/15/2018	0.41	6.6	NS	10.4	-6.7	-41.5

Notes:

‰ per thousand (per mil)

BDL Below Detection Limit

NS not sampled

\* Peak is small. Uncertainty is higher than usual.

mg/L milligrams per Liter

NBS National Bureau of Standards

[1] Results determined using Isotope Ratio Mass Spectrometry (IRMS) - MAT 253, Thermo Scientific, Germany, coupled with an Agilent 6890 Gas Chromatograph (GC). SMOC standard used. Typical standard deviation  $\pm 0.15$  ‰.

[2] Results determined using Isotope Ratio Mass Spectrometry (IRMS) - MAT 253, Thermo Scientific, Germany, coupled with Elemental Analyzer (EA), Fisons Instruments, Italy. IAEA-SO-6 / IT2-520 / IAEA-SO-5 / IT2-518 / NBS-127 standard used. Typical standard deviation:  $\pm 0.5$  ‰.

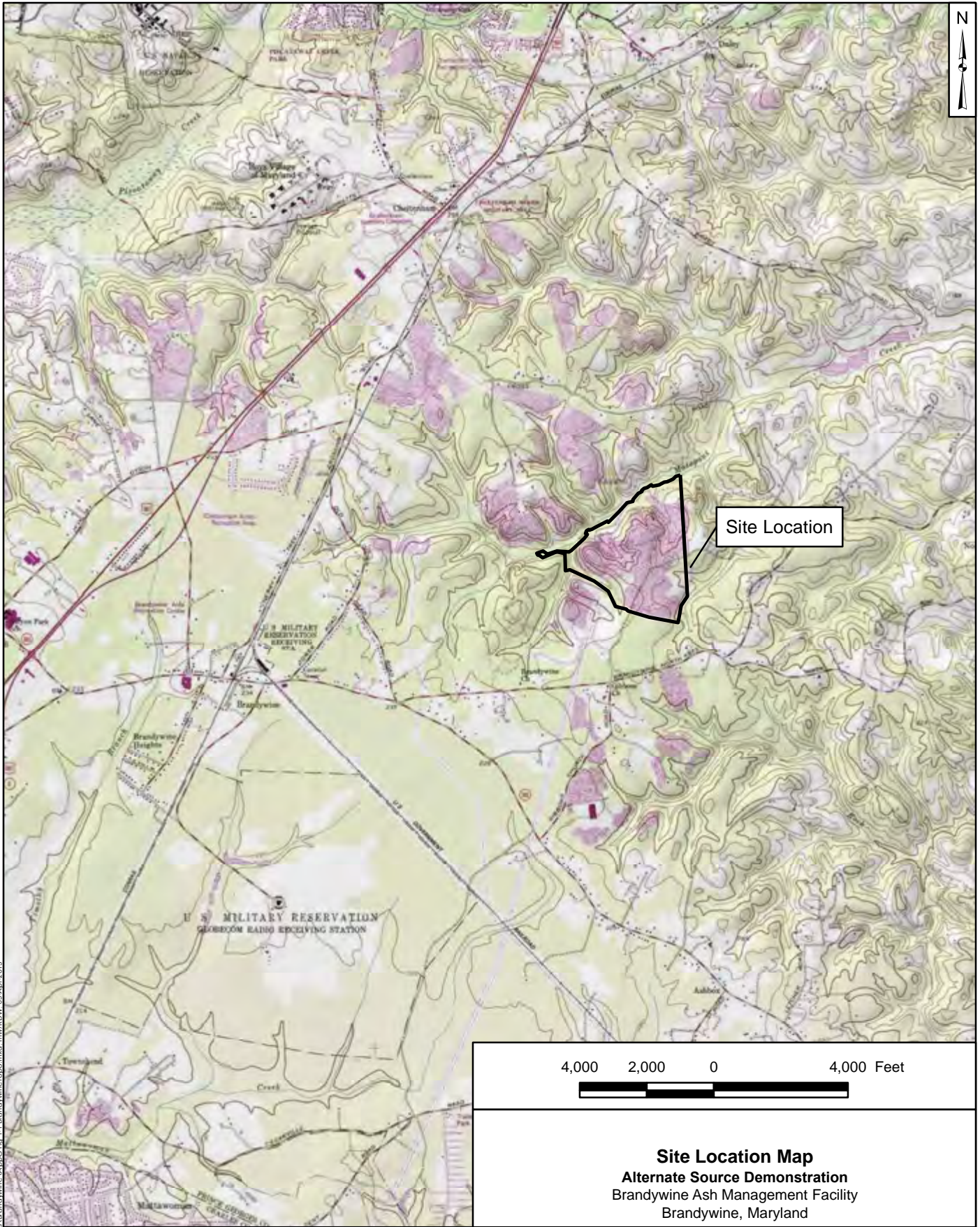
[3] Computed using NBS SRM 951. Correction is made for machine and extraction bias using results of NBS Standard analysis. Precision is given by the standard deviation from analysis of NBS standard

[4] Analyzed using Vienna Standard Mean Ocean Water (VSMOW).

[5] Duplicate sample collected.

# FIGURES





Site Location

4,000 2,000 0 4,000 Feet



**Site Location Map**  
 Alternate Source Demonstration  
 Brandywine Ash Management Facility  
 Brandywine, Maryland

Source:  
 USGS Topographic Quadrangle - Brandywine, Maryland,  
 provided by the National Geographic Society and i-cubed. © 2011  
 National Geographic Society, i-cubed

**Geosyntec**  
 consultants

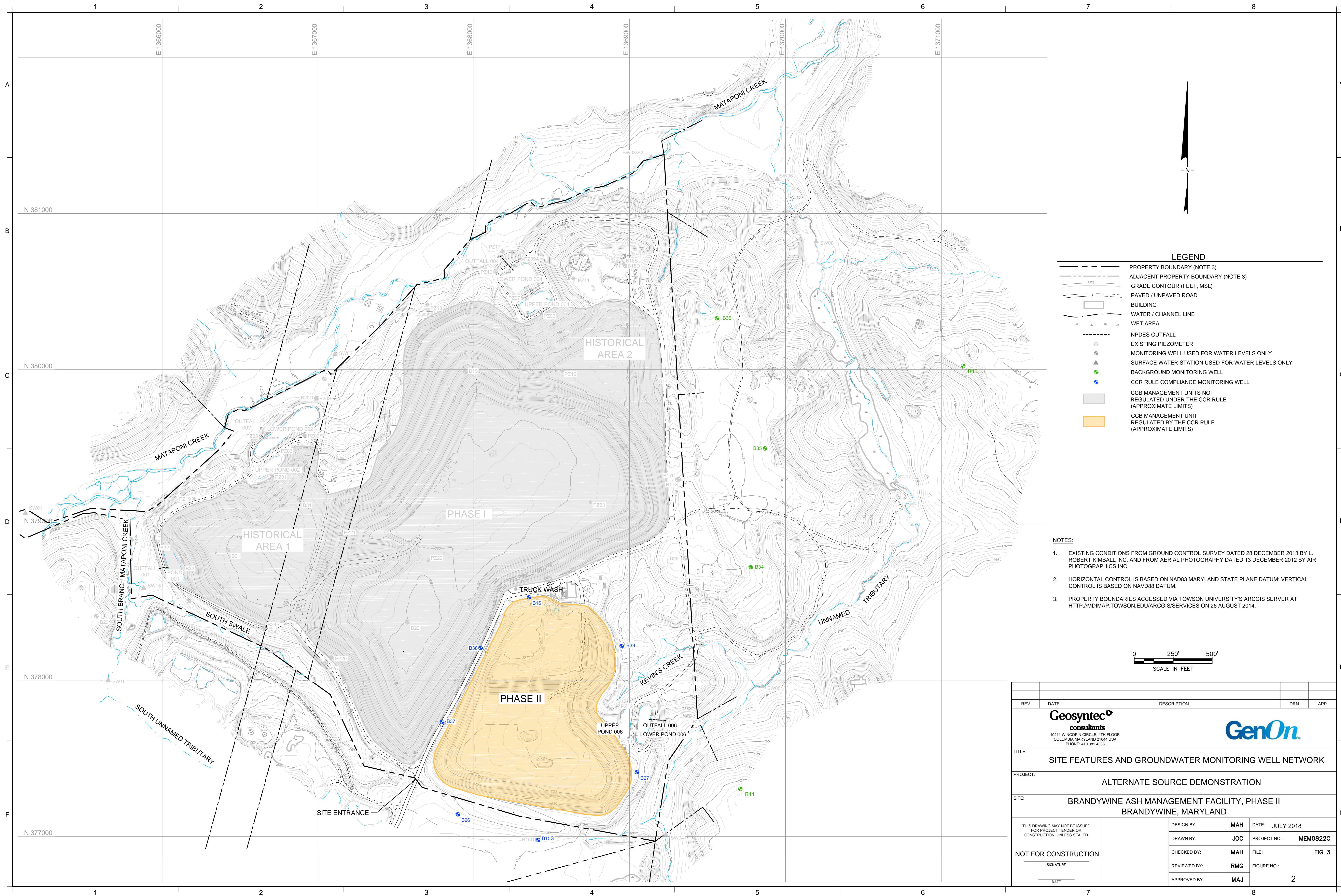
Figure

**1**

Columbia, Maryland

July 2018

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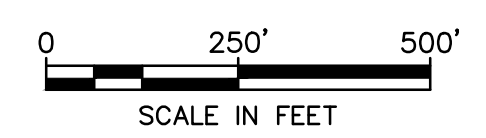


**LEGEND**

- PROPERTY BOUNDARY (NOTE 3)
- ADJACENT PROPERTY BOUNDARY (NOTE 3)
- GRADE CONTOUR (FEET, MSL)
- PAVED / UNPAVED ROAD
- BUILDING
- WATER / CHANNEL LINE
- WET AREA
- NPDES OUTFALL
- EXISTING PIEZOMETER
- MONITORING WELL USED FOR WATER LEVELS ONLY
- SURFACE WATER STATION USED FOR WATER LEVELS ONLY
- BACKGROUND MONITORING WELL
- CCR RULE COMPLIANCE MONITORING WELL
- CCB MANAGEMENT UNITS NOT REGULATED UNDER THE CCR RULE (APPROXIMATE LIMITS)
- CCB MANAGEMENT UNIT REGULATED BY THE CCR RULE (APPROXIMATE LIMITS)

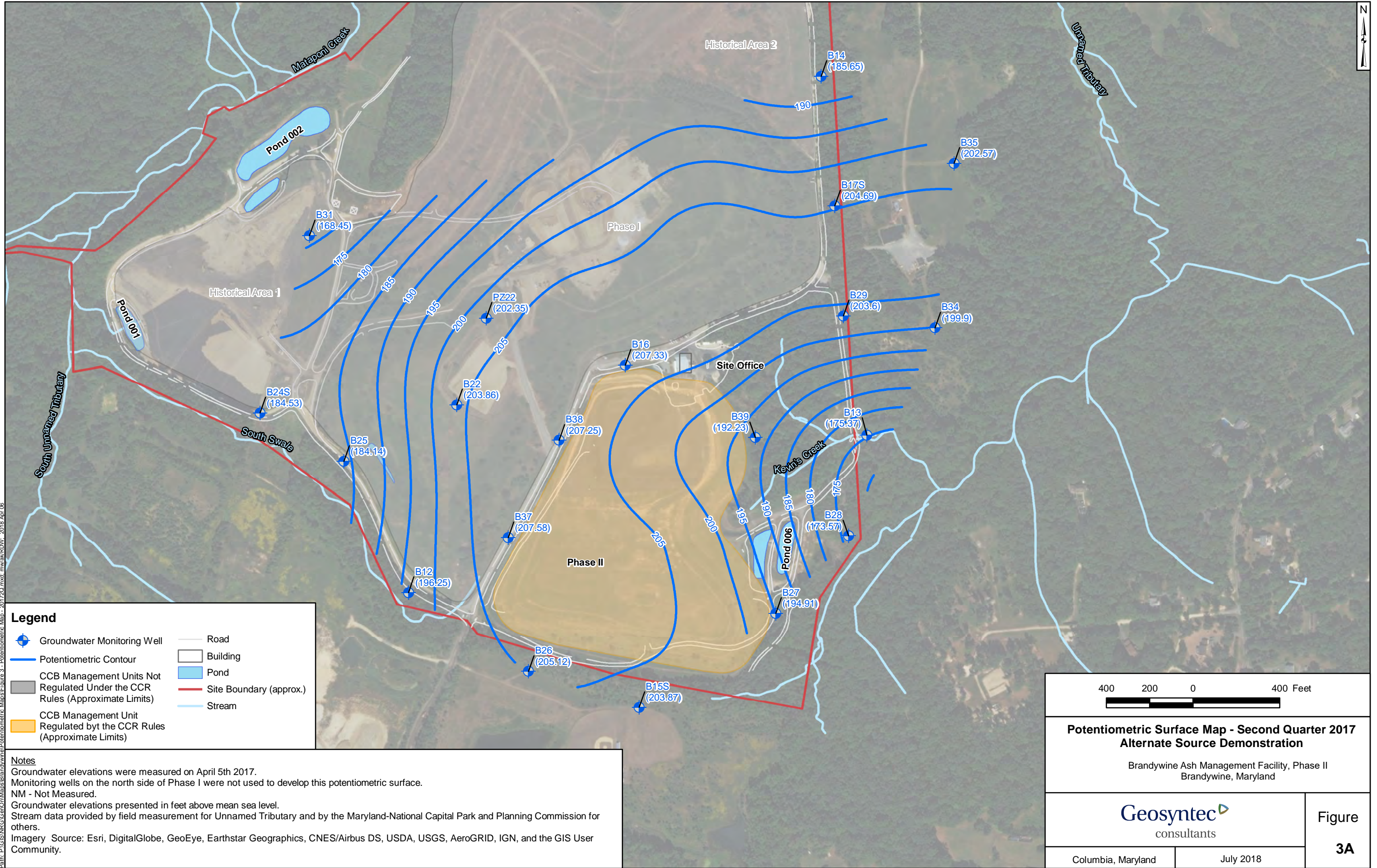
**NOTES:**

1. EXISTING CONDITIONS FROM GROUND CONTROL SURVEY DATED 28 DECEMBER 2013 BY L. ROBERT KIMBALL INC. AND FROM AERIAL PHOTOGRAPHY DATED 13 DECEMBER 2012 BY AIR PHOTOGRAPHICS INC.
2. HORIZONTAL CONTROL IS BASED ON NAD83 MARYLAND STATE PLANE DATUM; VERTICAL CONTROL IS BASED ON NAVD88 DATUM.
3. PROPERTY BOUNDARIES ACCESSED VIA TOWSON UNIVERSITY'S ARCGIS SERVER AT [HTTP://MDIMAP.TOWSON.EDU/ARCGIS/SERVICES](http://mdimap.towson.edu/arcgis/services) ON 26 AUGUST 2014.



REV	DATE	DESCRIPTION	DRN	APP
<small>10211 WINDOPIN CIRCLE, 4TH FLOOR COLUMBIA MARYLAND 21044 USA PHONE: 410.381.4333</small>				
<b>TITLE:</b> SITE FEATURES AND GROUNDWATER MONITORING WELL NETWORK				
<b>PROJECT:</b> ALTERNATE SOURCE DEMONSTRATION				
<b>SITE:</b> BRANDYWINE ASH MANAGEMENT FACILITY, PHASE II BRANDYWINE, MARYLAND				
<small>THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION UNLESS SEALED.</small>		<b>DESIGN BY:</b> MAH <b>DRAWN BY:</b> JOC <b>CHECKED BY:</b> MAH <b>REVIEWED BY:</b> RMG <b>APPROVED BY:</b> MAJ	<b>DATE:</b> JULY 2018 <b>PROJECT NO.:</b> MEM0822C <b>FILE:</b> FIG 3 <b>FIGURE NO.:</b> 2	
<b>NOT FOR CONSTRUCTION</b>				
SIGNATURE				
DATE				

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 Mwh



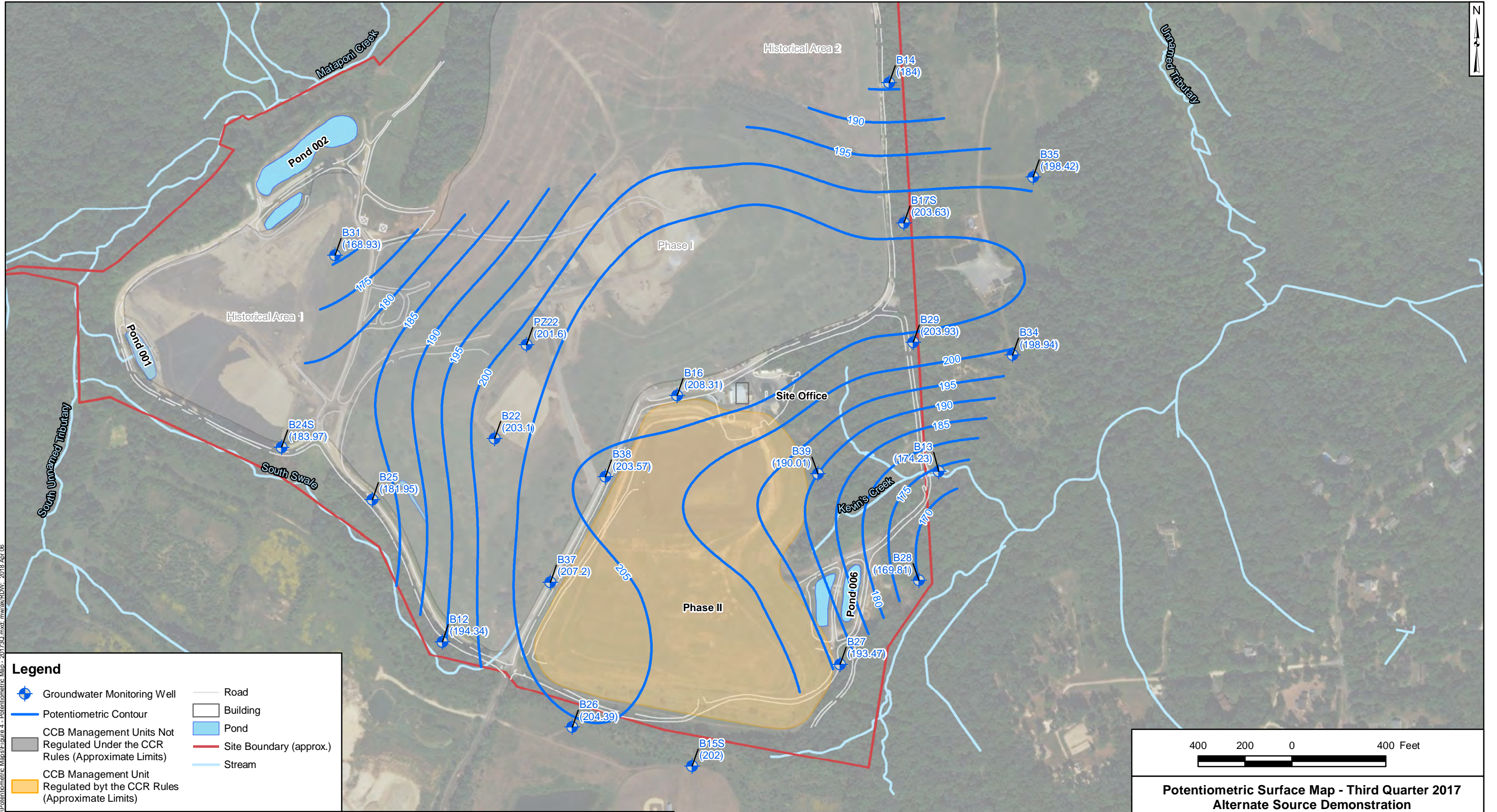
Path: P:\GIS\NRG\GenOn\Mapas\Brandywine\Potentiometric Maps\Figure 3 - Potentiometric Map - 2017Q2.mxd; mw:alw/RDW; 2018 Apr 06

**Legend**

- Groundwater Monitoring Well
- Potentiometric Contour
- CCB Management Units Not Regulated Under the CCR Rules (Approximate Limits)
- CCB Management Unit Regulated by the CCR Rules (Approximate Limits)
- Road
- Building
- Pond
- Site Boundary (approx.)
- Stream

**Notes**  
 Groundwater elevations were measured on April 5th 2017.  
 Monitoring wells on the north side of Phase I were not used to develop this potentiometric surface.  
 NM - Not Measured.  
 Groundwater elevations presented in feet above mean sea level.  
 Stream data provided by field measurement for Unnamed Tributary and by the Maryland-National Capital Park and Planning Commission for others.  
 Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

<p><b>Potentiometric Surface Map - Second Quarter 2017          Alternate Source Demonstration</b></p> <p>Brandywine Ash Management Facility, Phase II          Brandywine, Maryland</p>	
Columbia, Maryland	July 2018
<p>Figure <b>3A</b></p>	



Path: P:\GIS\NRG\GenOn\Mapa\Brandywine\Potentiometric Maps\Figure 4 - Potentiometric Map - 201709.mxd mwalsh\RDW - 2018 Apr 06

**Legend**

<ul style="list-style-type: none"> <li> Groundwater Monitoring Well</li> <li> Potentiometric Contour</li> <li> CCB Management Units Not Regulated Under the CCR Rules (Approximate Limits)</li> <li> CCB Management Unit Regulated by the CCR Rules (Approximate Limits)</li> </ul>	<ul style="list-style-type: none"> <li> Road</li> <li> Building</li> <li> Pond</li> <li> Site Boundary (approx.)</li> <li> Stream</li> </ul>
---	--

**Notes**  
 Groundwater elevations were measured on July 25th and 26th 2017.  
 Monitoring wells on the north side of Phase I were not used to develop this potentiometric surface.  
 NM - Not Measured.  
 Groundwater elevations presented in feet above mean sea level.  
 Stream data provided by field measurement for Unnamed Tributary and by the Maryland-National Capital Park and Planning Commission for others.  
 Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

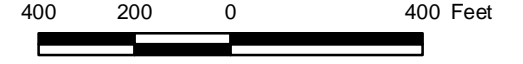
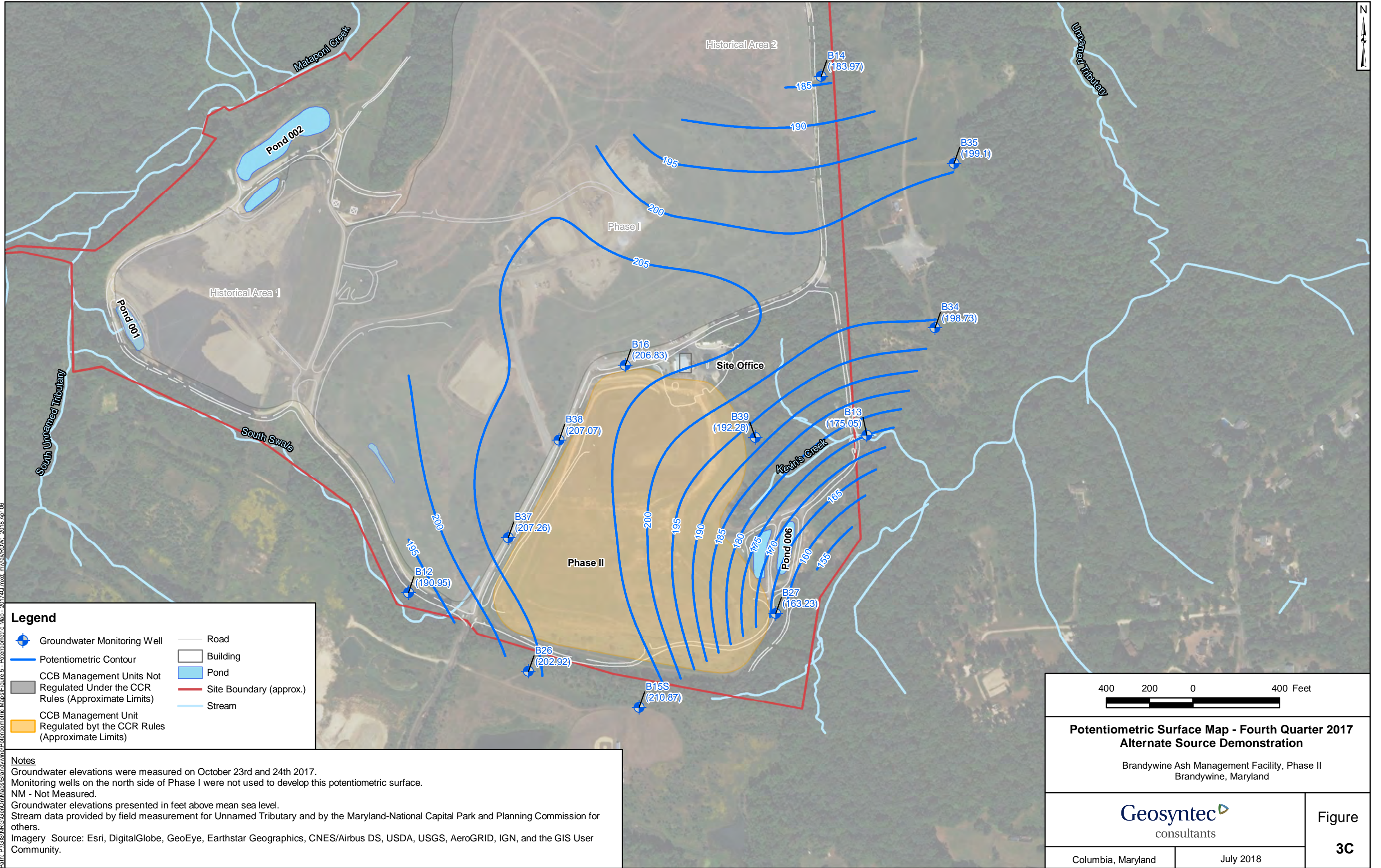
  
**Potentiometric Surface Map - Third Quarter 2017**  
**Alternate Source Demonstration**  
 Brandywine Ash Management Facility, Phase II  
 Brandywine, Maryland

		Figure
Columbia, Maryland	July 2018	<b>3B</b>



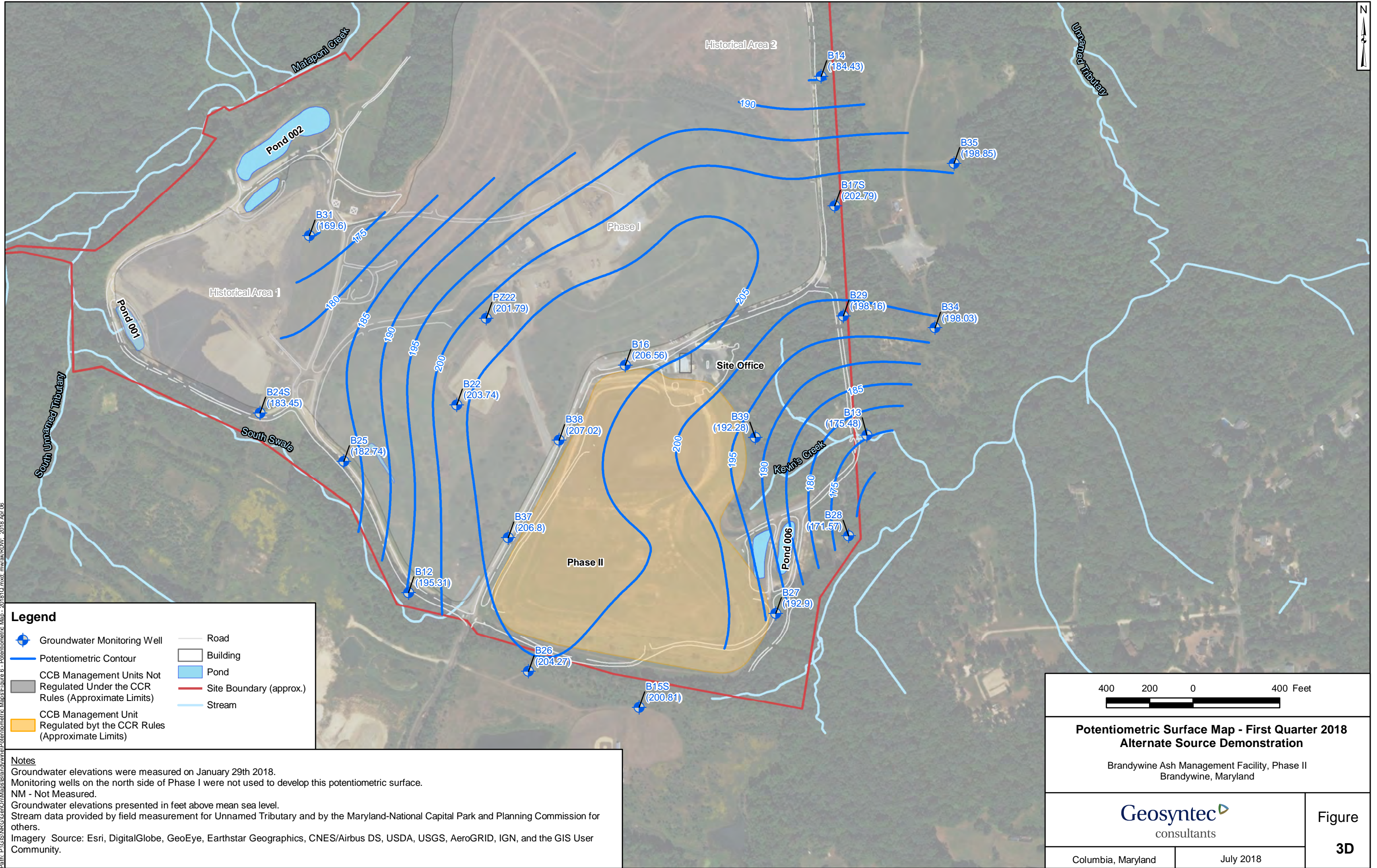
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**Legend**

- Groundwater Monitoring Well
- Potentiometric Contour
- CCB Management Units Not Regulated Under the CCR Rules (Approximate Limits)
- CCB Management Unit Regulated by the CCR Rules (Approximate Limits)
- Road
- Building
- Pond
- Site Boundary (approx.)
- Stream

**Notes**  
 Groundwater elevations were measured on October 23rd and 24th 2017.  
 Monitoring wells on the north side of Phase I were not used to develop this potentiometric surface.  
 NM - Not Measured.  
 Groundwater elevations presented in feet above mean sea level.  
 Stream data provided by field measurement for Unnamed Tributary and by the Maryland-National Capital Park and Planning Commission for others.  
 Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

<b>Potentiometric Surface Map - Fourth Quarter 2017</b> <b>Alternate Source Demonstration</b>  Brandywine Ash Management Facility, Phase II Brandywine, Maryland	
Columbia, Maryland	July 2018
<b>Figure</b>  <b>3C</b>	



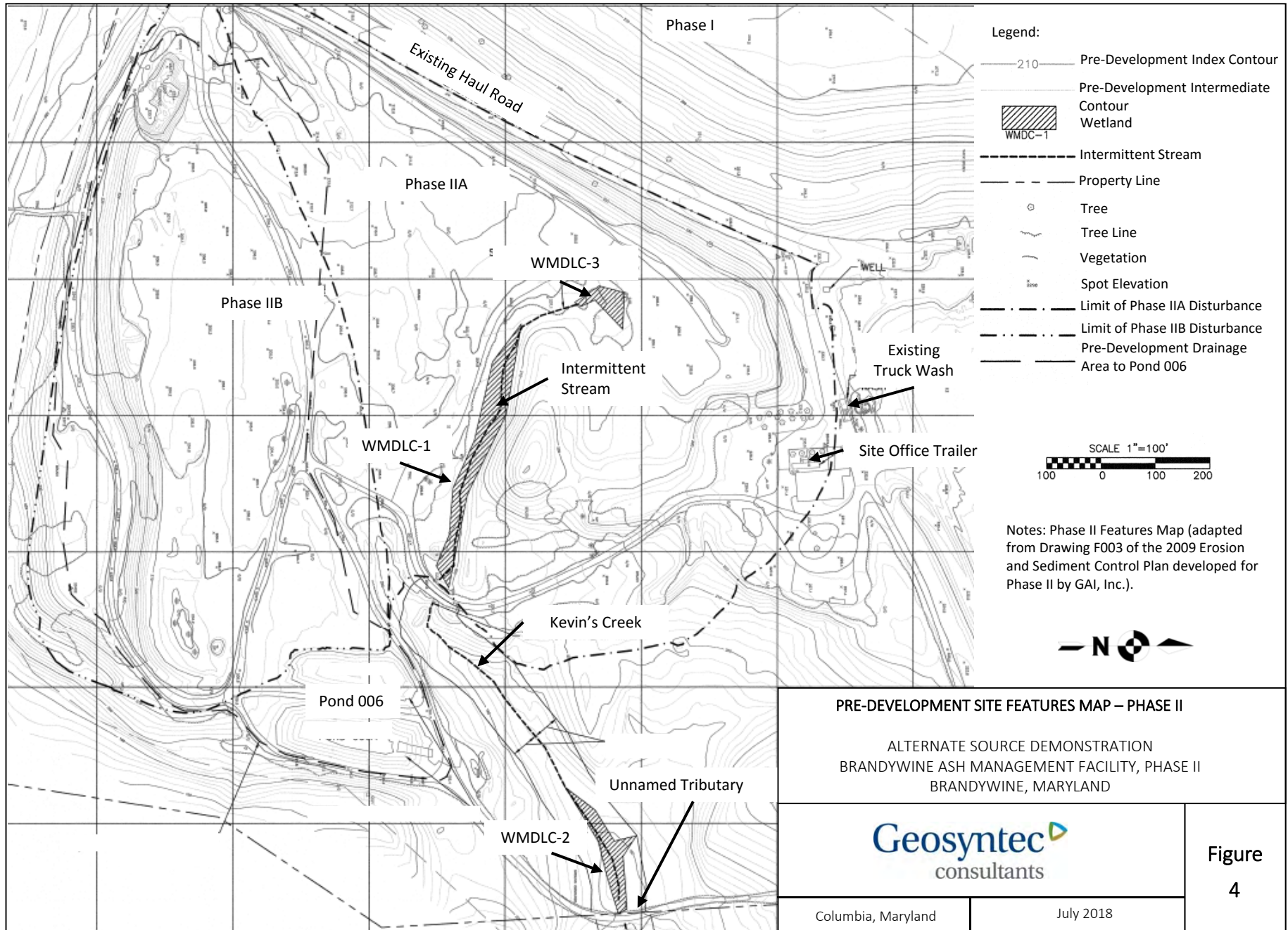
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**Legend**

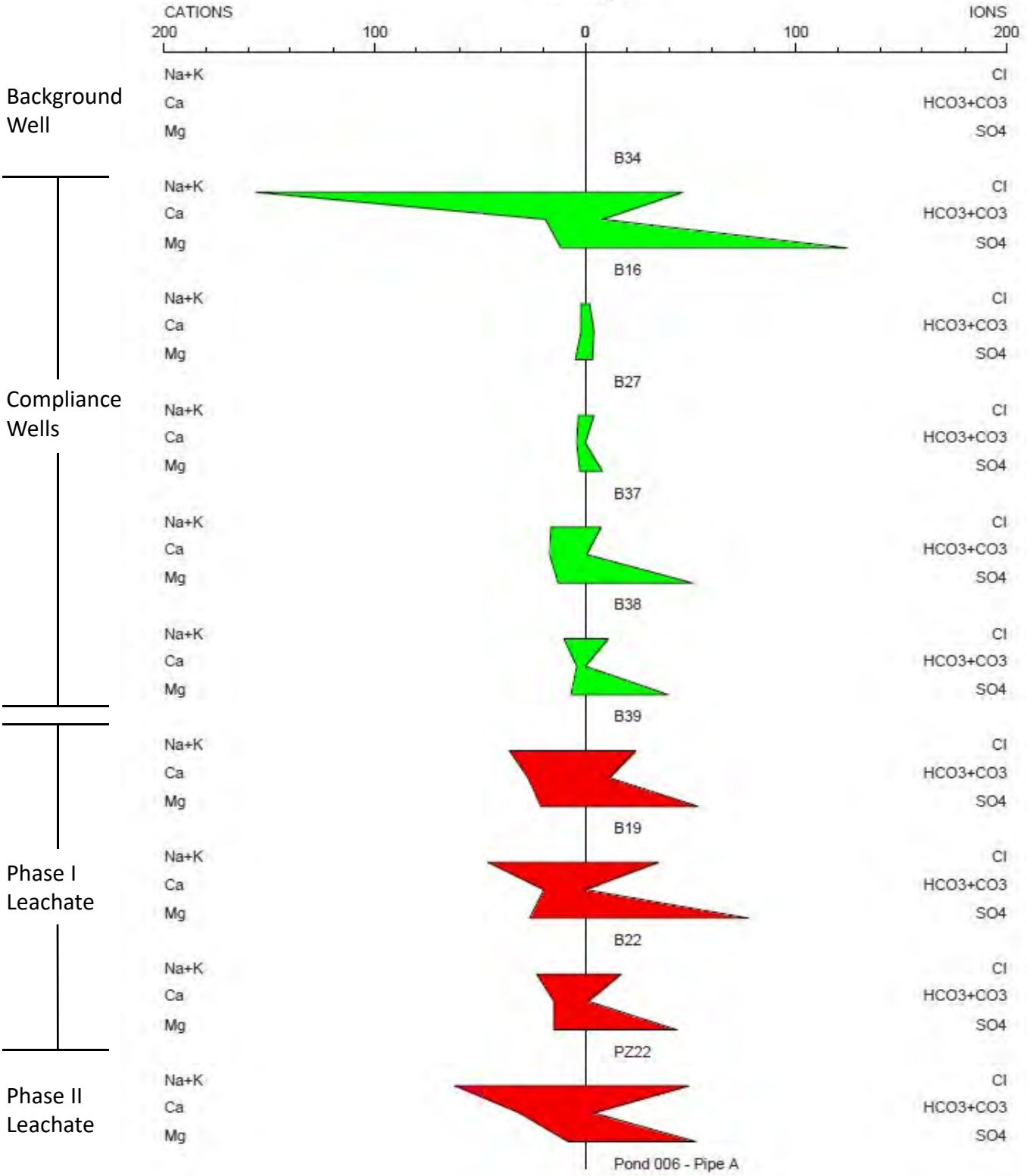
- Groundwater Monitoring Well
- Potentiometric Contour
- CCB Management Units Not Regulated Under the CCR Rules (Approximate Limits)
- CCB Management Unit Regulated by the CCR Rules (Approximate Limits)
- Road
- Building
- Pond
- Site Boundary (approx.)
- Stream

**Notes**  
 Groundwater elevations were measured on January 29th 2018.  
 Monitoring wells on the north side of Phase I were not used to develop this potentiometric surface.  
 NM - Not Measured.  
 Groundwater elevations presented in feet above mean sea level.  
 Stream data provided by field measurement for Unnamed Tributary and by the Maryland-National Capital Park and Planning Commission for others.  
 Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

<b>Potentiometric Surface Map - First Quarter 2018</b> <b>Alternate Source Demonstration</b>	
Brandywine Ash Management Facility, Phase II Brandywine, Maryland	
Columbia, Maryland	July 2018
<b>Figure 3D</b>	



### Stiff Diagram

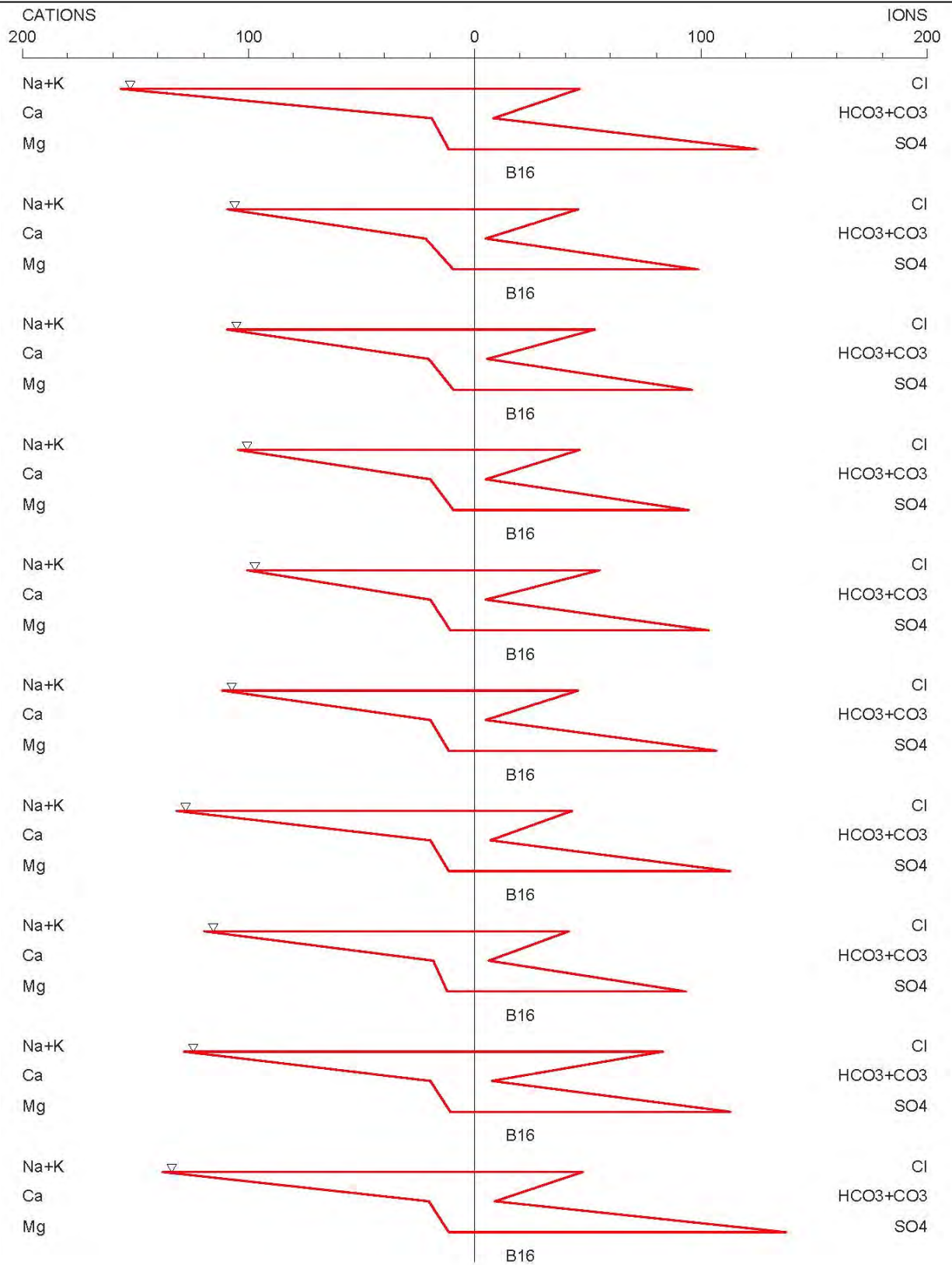


STIFF DIAGRAMS FOR JANUARY 2018 BACKGROUND, COMPLIANCE, PHASE I, and PHASE II LEACHATE  
ALTERNATE SOURCE DEMONSTRATION  
BRANDYWINE ASH MANAGEMENT FACILITY, PHASE II  
BRANDYWINE, MARYLAND



Figure  
5A





**STIFF DIAGRAM FOR GROUNDWATER MONITORING WELL B16**

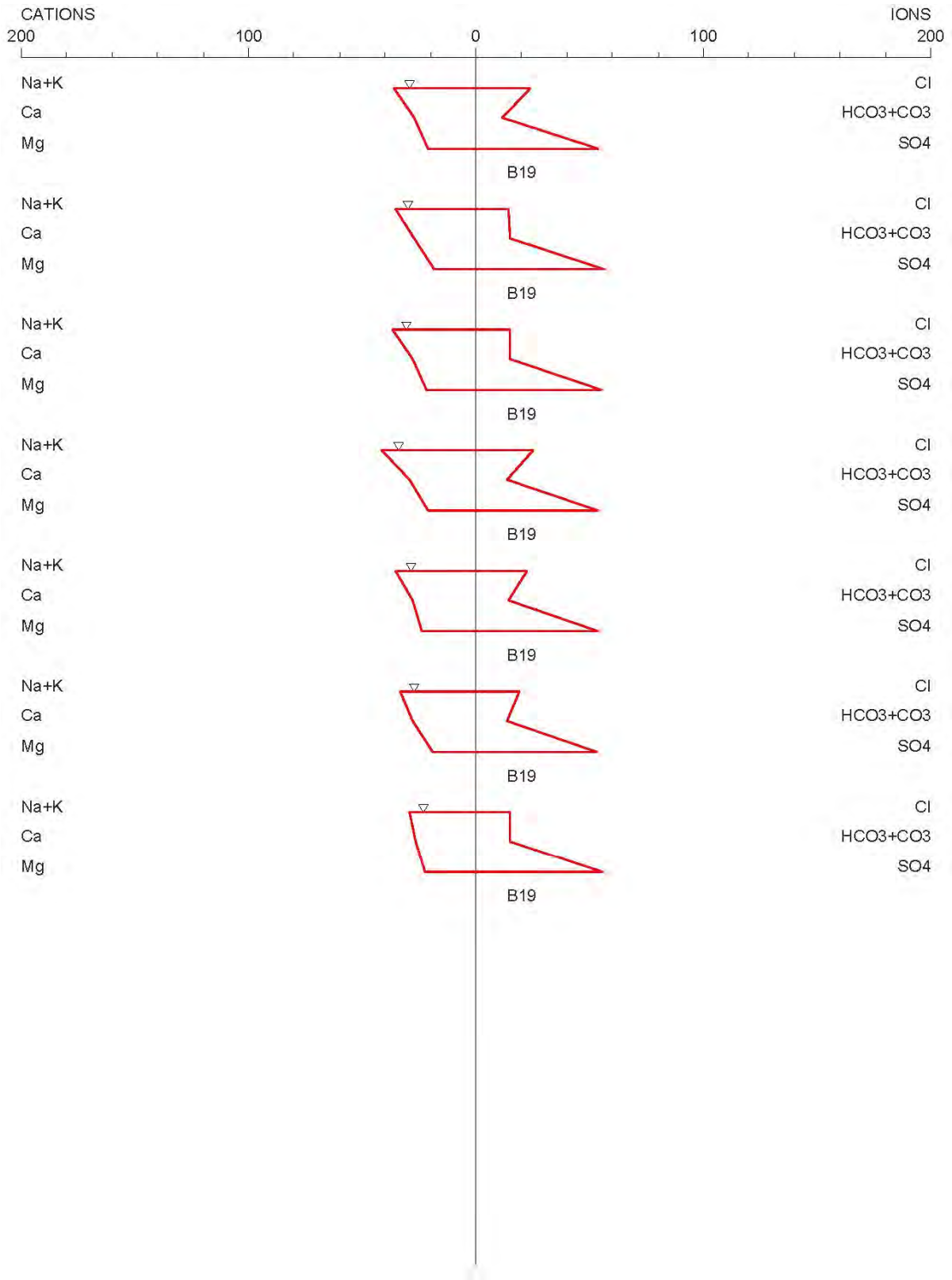
ALTERNATE SOURCE DEMONSTRATION  
 BRANDYWINE ASH MANAGEMENT FACILITY, PHASE II  
 BRANDYWINE, MARYLAND



**Figure  
5B**

Columbia, Maryland

July 2018



**STIFF DIAGRAM FOR GROUNDWATER MONITORING WELL B19**

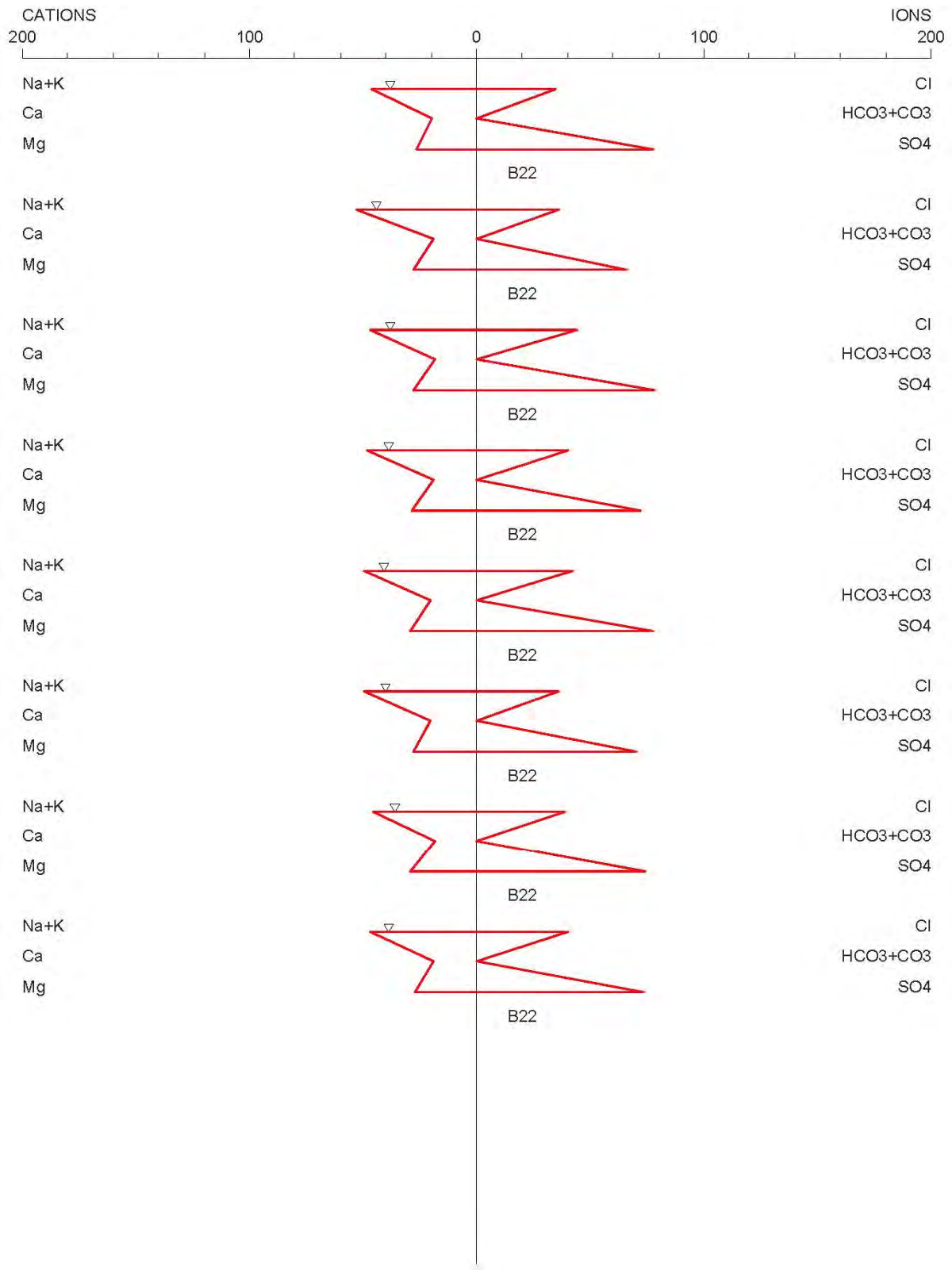
ALTERNATE SOURCE DEMONSTRATION  
 BRANDYWINE ASH MANAGEMENT FACILITY, PHASE II  
 BRANDYWINE, MARYLAND



**Figure  
5C**

Columbia, Maryland

July 2018



STIFF DIAGRAM FOR GROUNDWATER MONITORING WELL B22

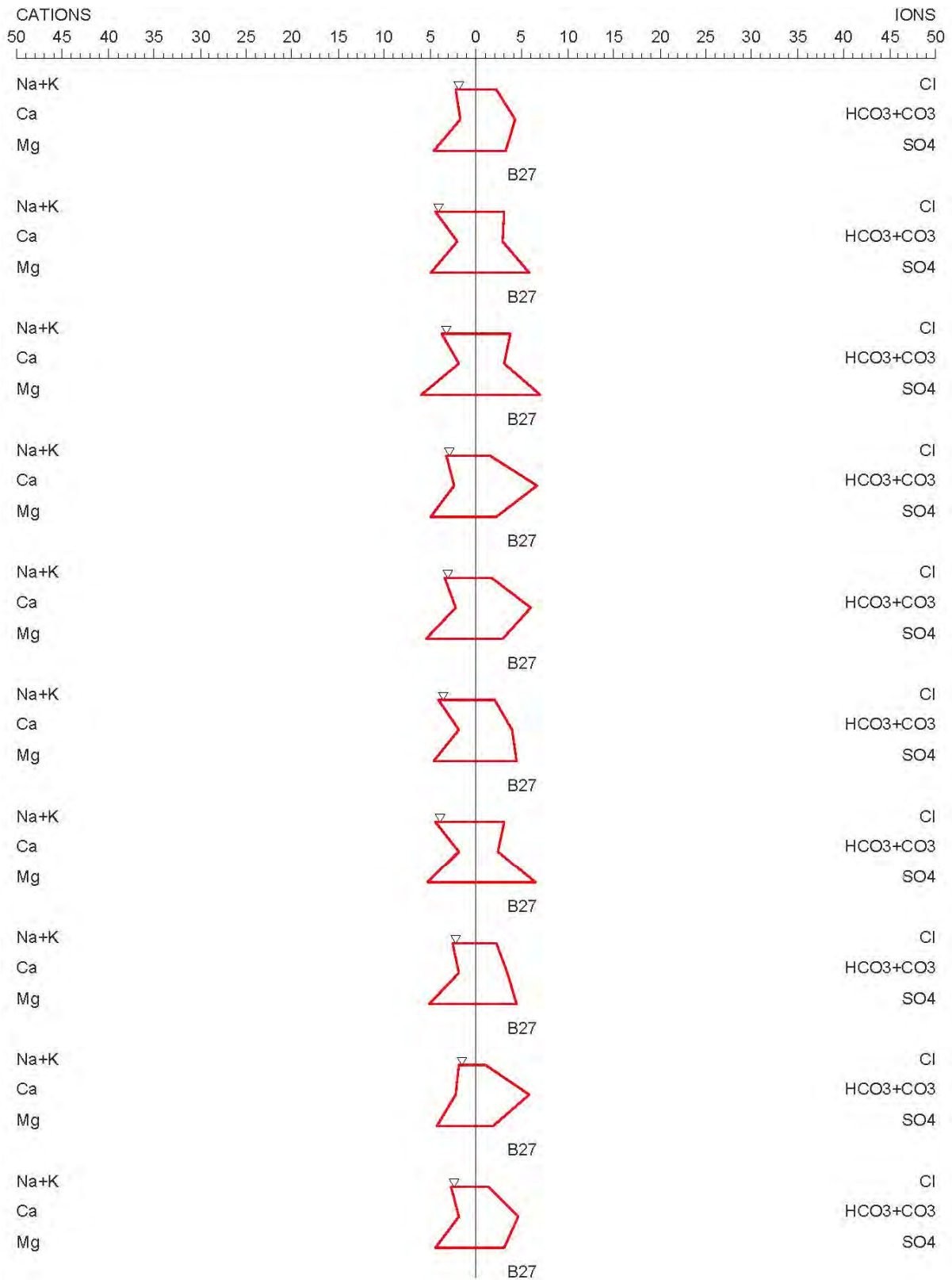
ALTERNATE SOURCE DEMONSTRATION  
 BRANDYWINE ASH MANAGEMENT FACILITY, PHASE II  
 BRANDYWINE, MARYLAND

Geosyntec  
 consultants

Figure  
 5D

Columbia, Maryland

July 2018



STIFF DIAGRAM FOR GROUNDWATER MONITORING WELL B27

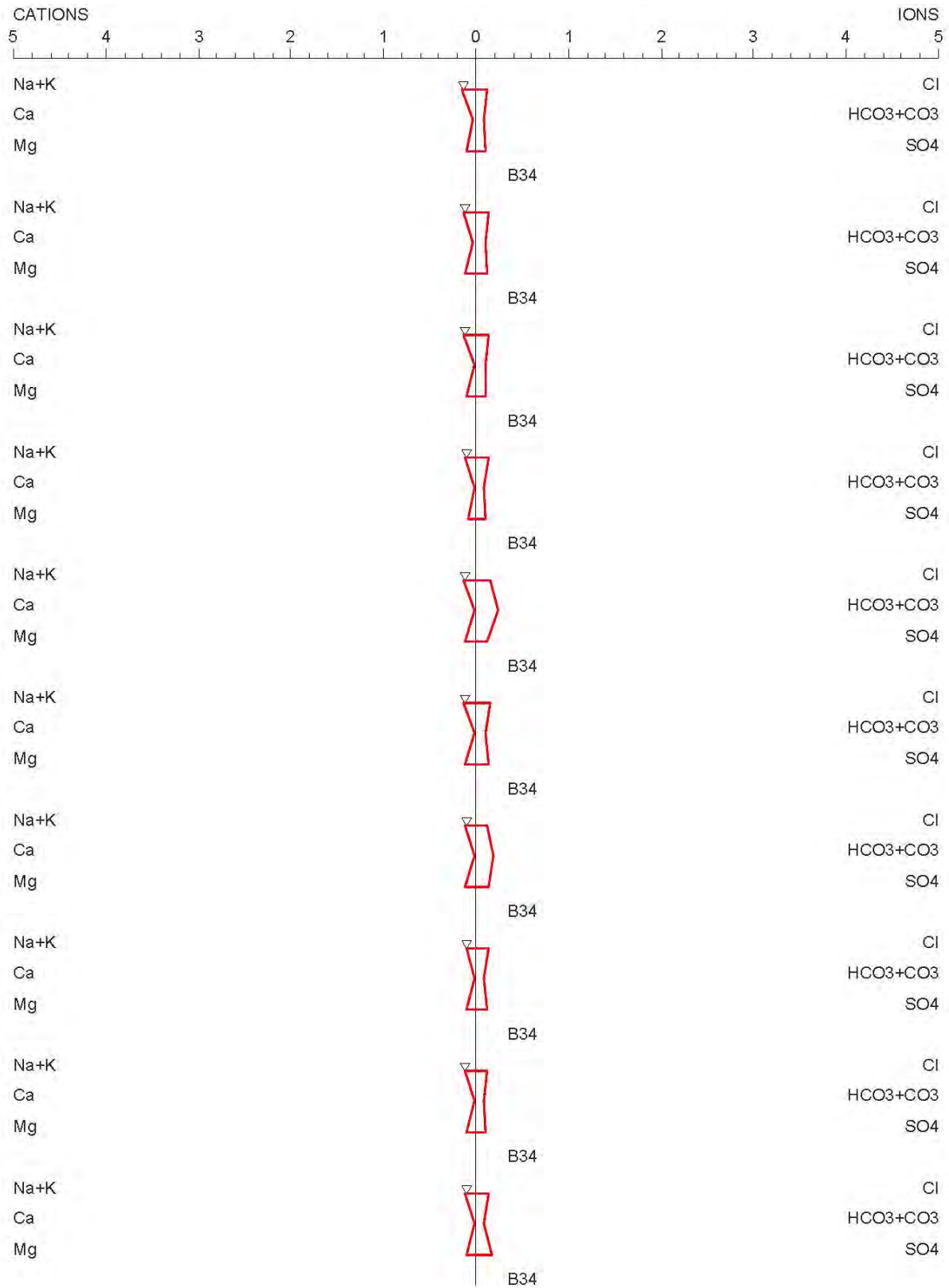
ALTERNATE SOURCE DEMONSTRATION  
BRANDYWINE ASH MANAGEMENT FACILITY, PHASE II  
BRANDYWINE, MARYLAND

Geosyntec  
consultants

Figure  
5E

Columbia, Maryland

July 2018



STIFF DIAGRAM FOR GROUNDWATER MONITORING WELL B34

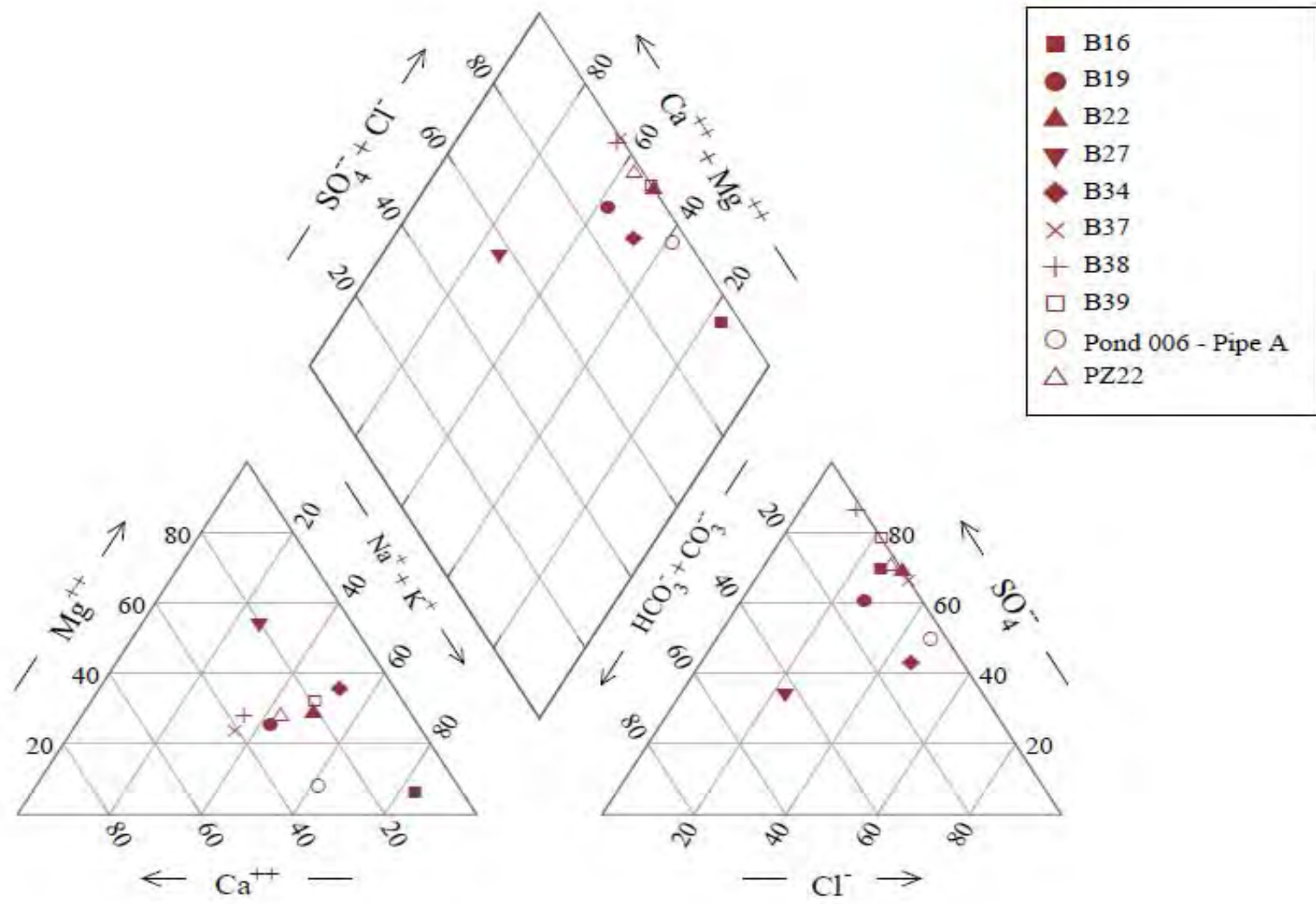
ALTERNATE SOURCE DEMONSTRATION  
 BRANDYWINE ASH MANAGEMENT FACILITY, PHASE II  
 BRANDYWINE, MARYLAND



Figure  
 5F

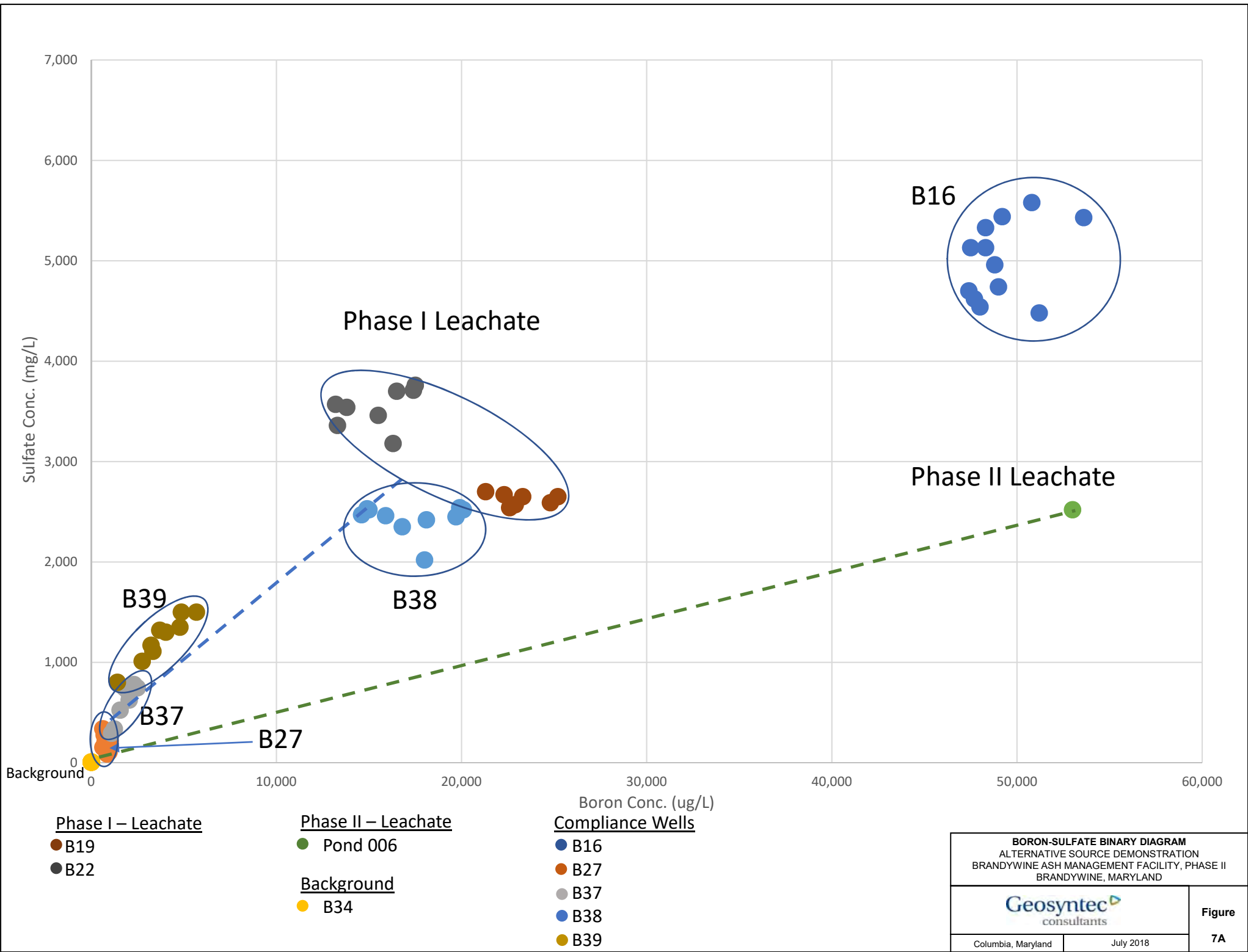
Columbia, Maryland

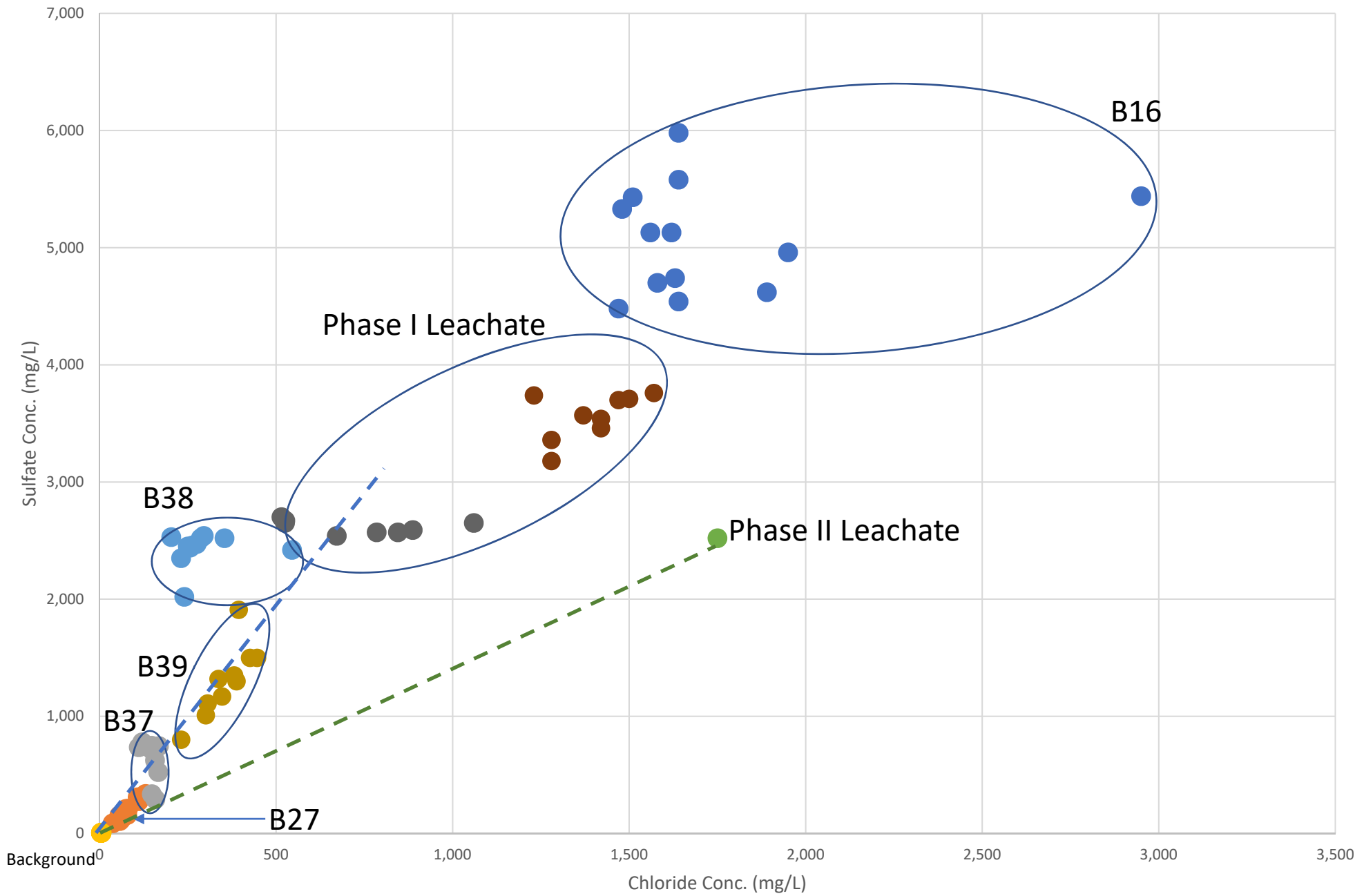
July 2018



% meq/kg

PIPER DIAGRAM – JANUARY 2018 SAMPLES  
 ALTERNATE SOURCE DEMONSTRATION  
 BRANDYWINE ASH MANAGEMENT FACILITY, PHASE II  
 BRANDYWINE, MARYLAND





Phase I – Leachate

- B19
- B22

Phase II – Leachate

- Pond 006

Background

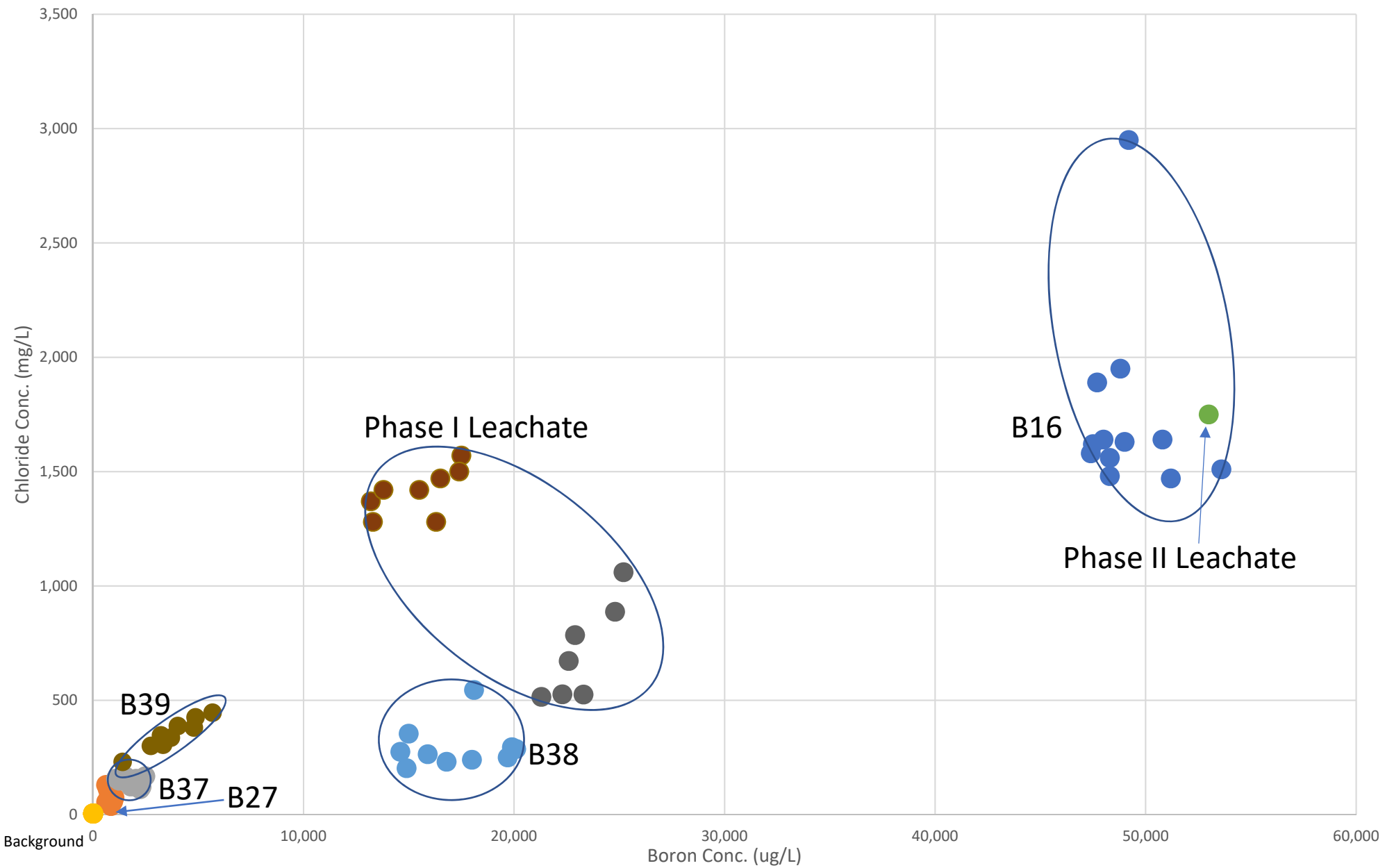
- B34

Compliance Wells

- B16
- B27
- B37
- B38
- B39

<b>SULFATE-CHLORIDE BINARY DIAGRAM</b> ALTERNATE SOURCE DEMONSTRATION BRANDYWINE ASH MANAGEMENT FACILITY, PHASE II BRANDYWINE, MARYLAND	
Columbia, Maryland	July 2018
<b>Figure</b> <b>7B</b>	





Phase I – Leachate

- B19
- B22

Phase II – Leachate

- Pond 006

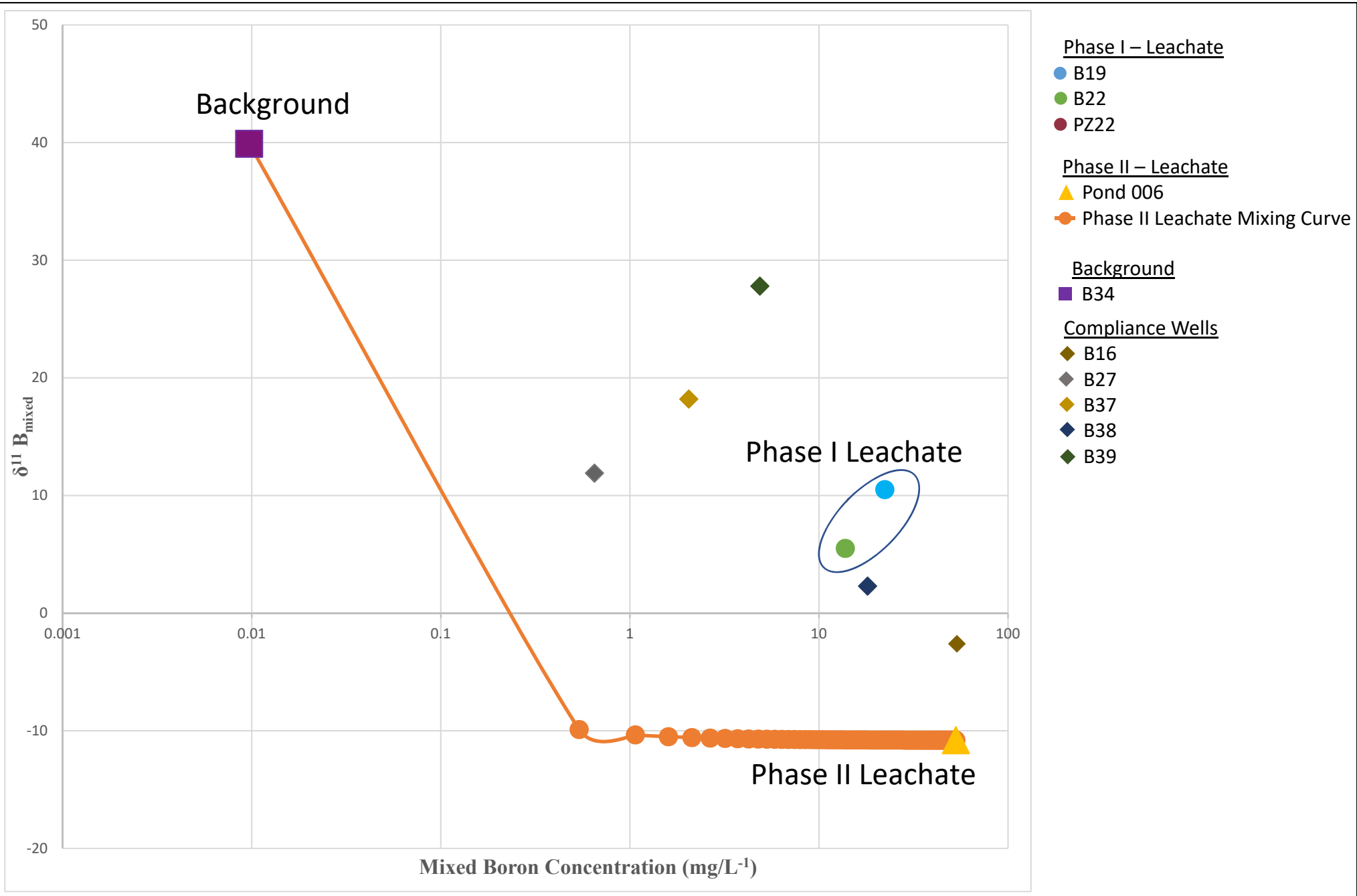
Background

- B34

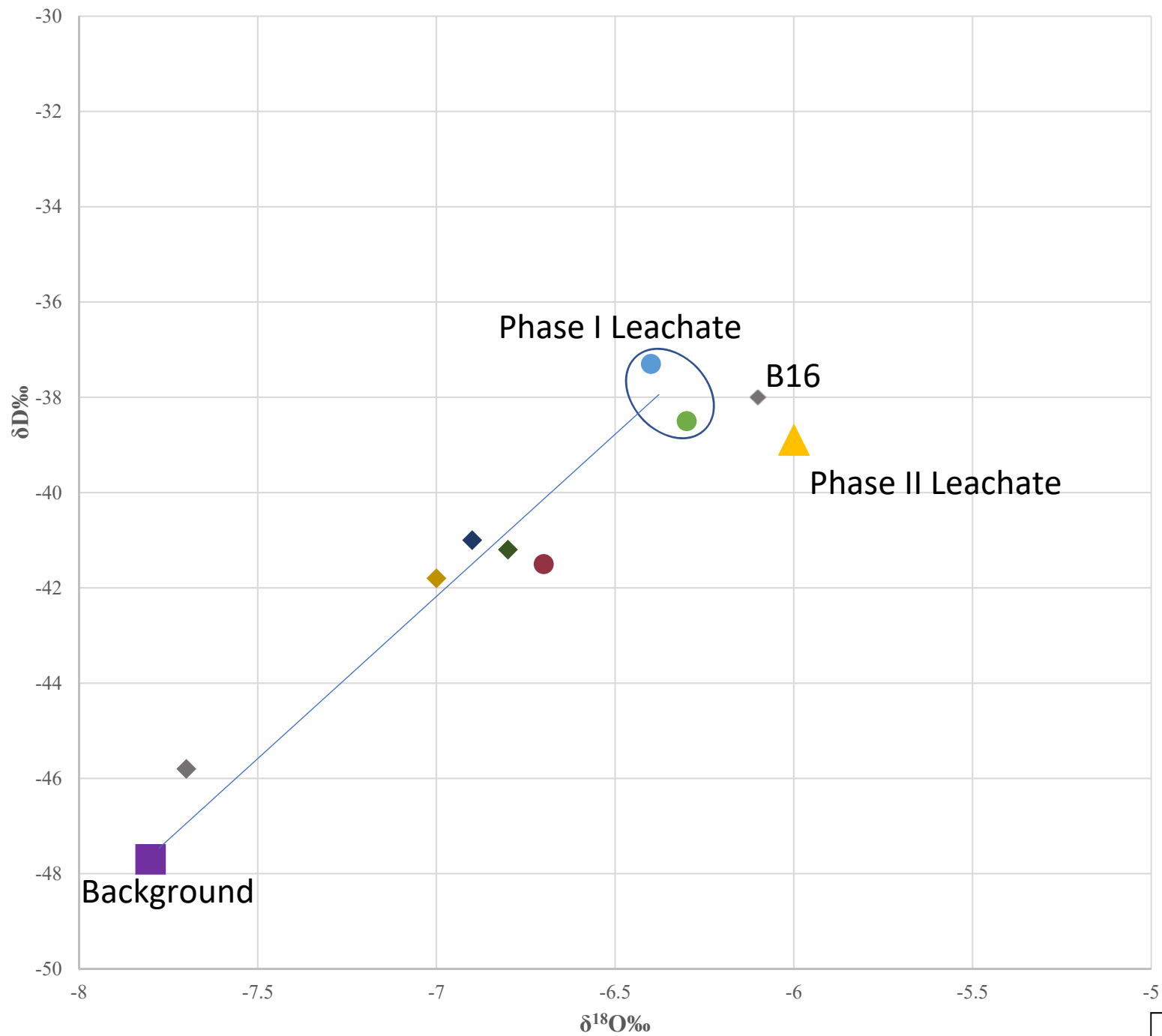
Compliance Wells

- B16
- B27
- B37
- B38
- B39

<b>BORON-CHLORIDE BINARY DIAGRAM</b> ALTERNATE SOURCE DEMONSTRATION BRANDYWINE ASH MANAGEMENT FACILITY, PHASE II BRANDYWINE, MARYLAND	
Columbia, Maryland	July 2018
<b>Figure</b> <b>7C</b>	

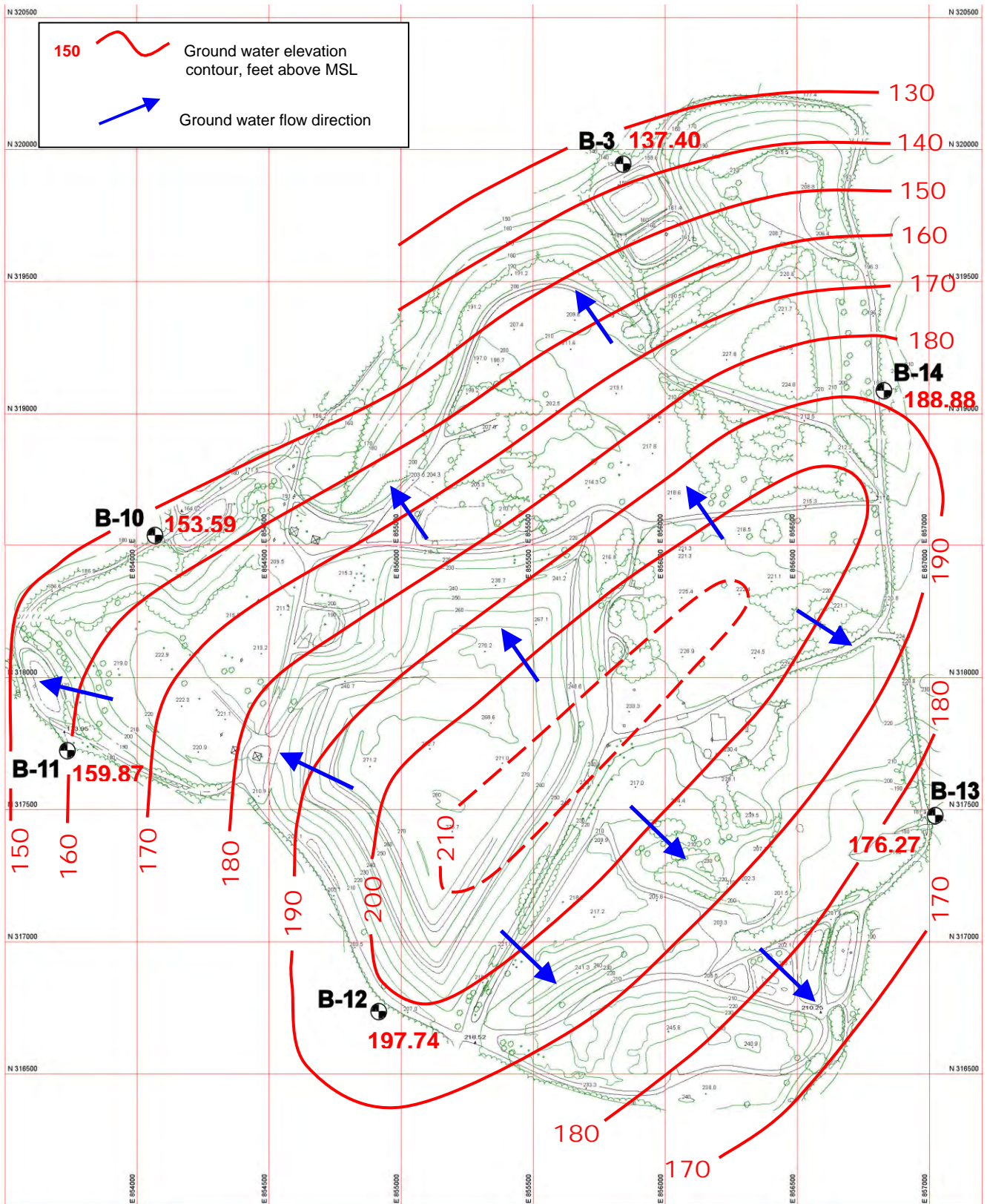


**PHASE II – BACKGROUND BORON MIXING DIAGRAM**  
 ALTERNATE SOURCE DEMONSTRATION  
 BRANDYWINE ASH MANAGEMENT FACILITY, PHASE II  
 BRANDYWINE, MARYLAND

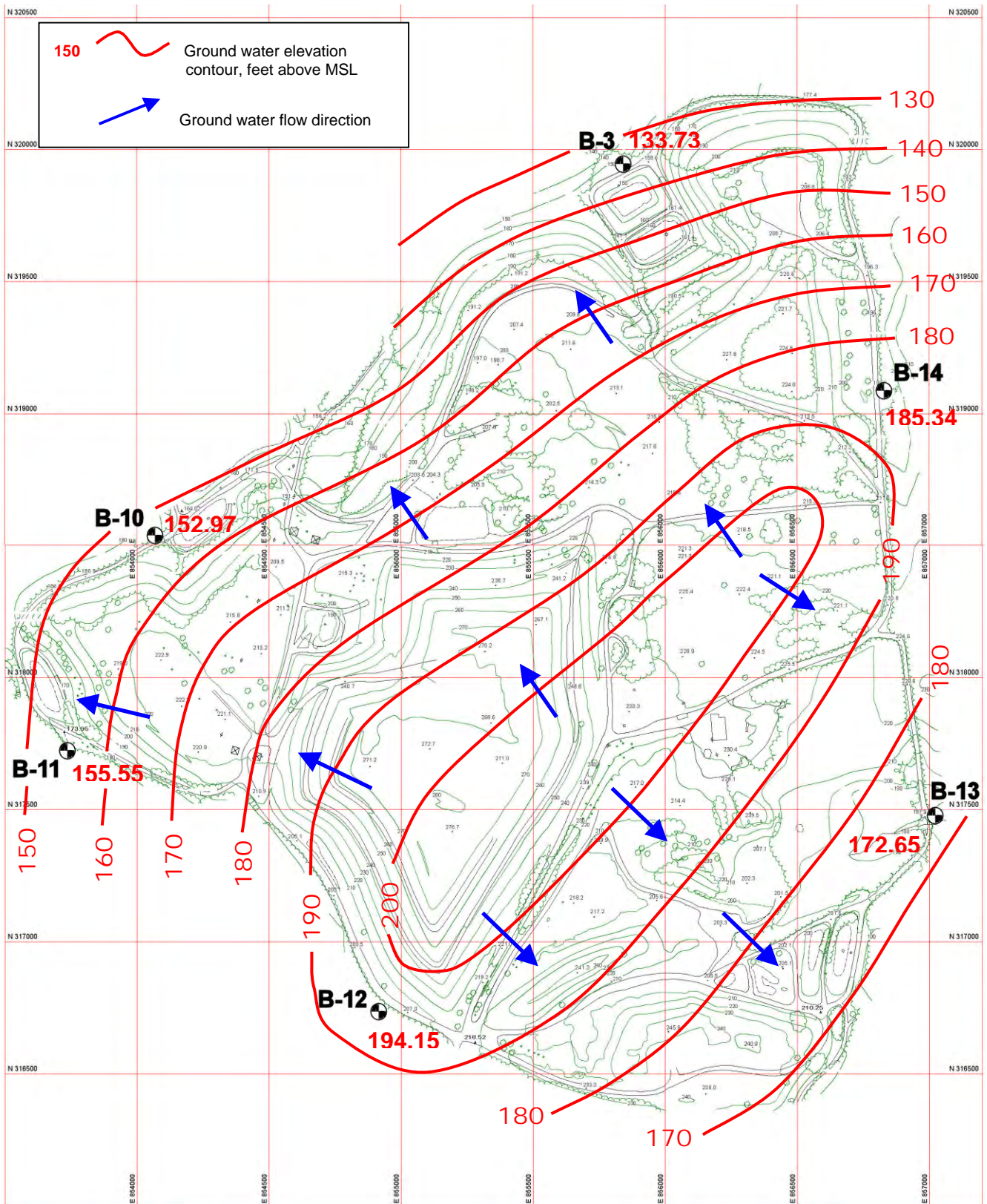


## APPENDIX A

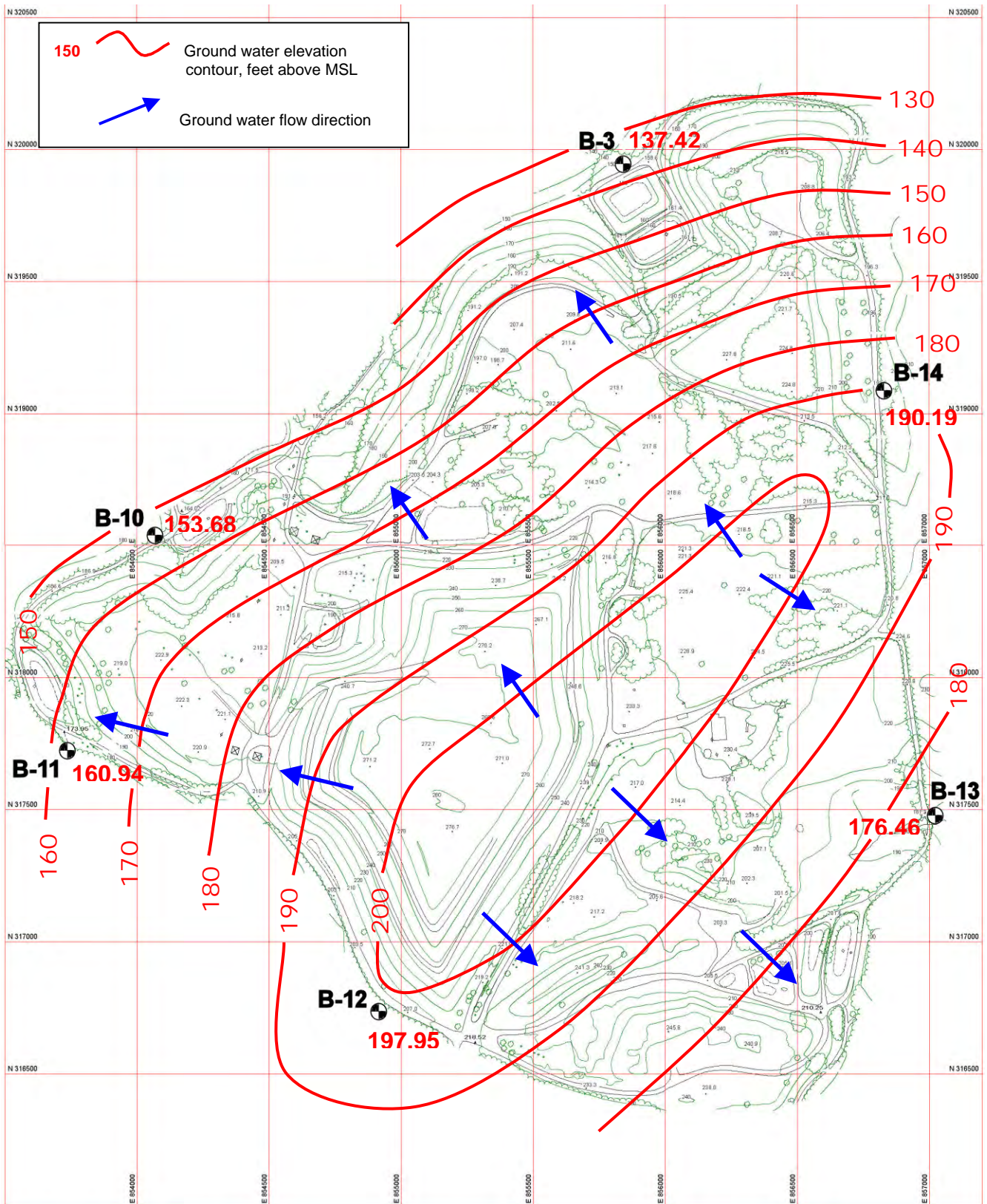
# HISTORICALAL POTENTIOMETRIC SURFACE MAPS (Porter, W.M. and Company, 2009)



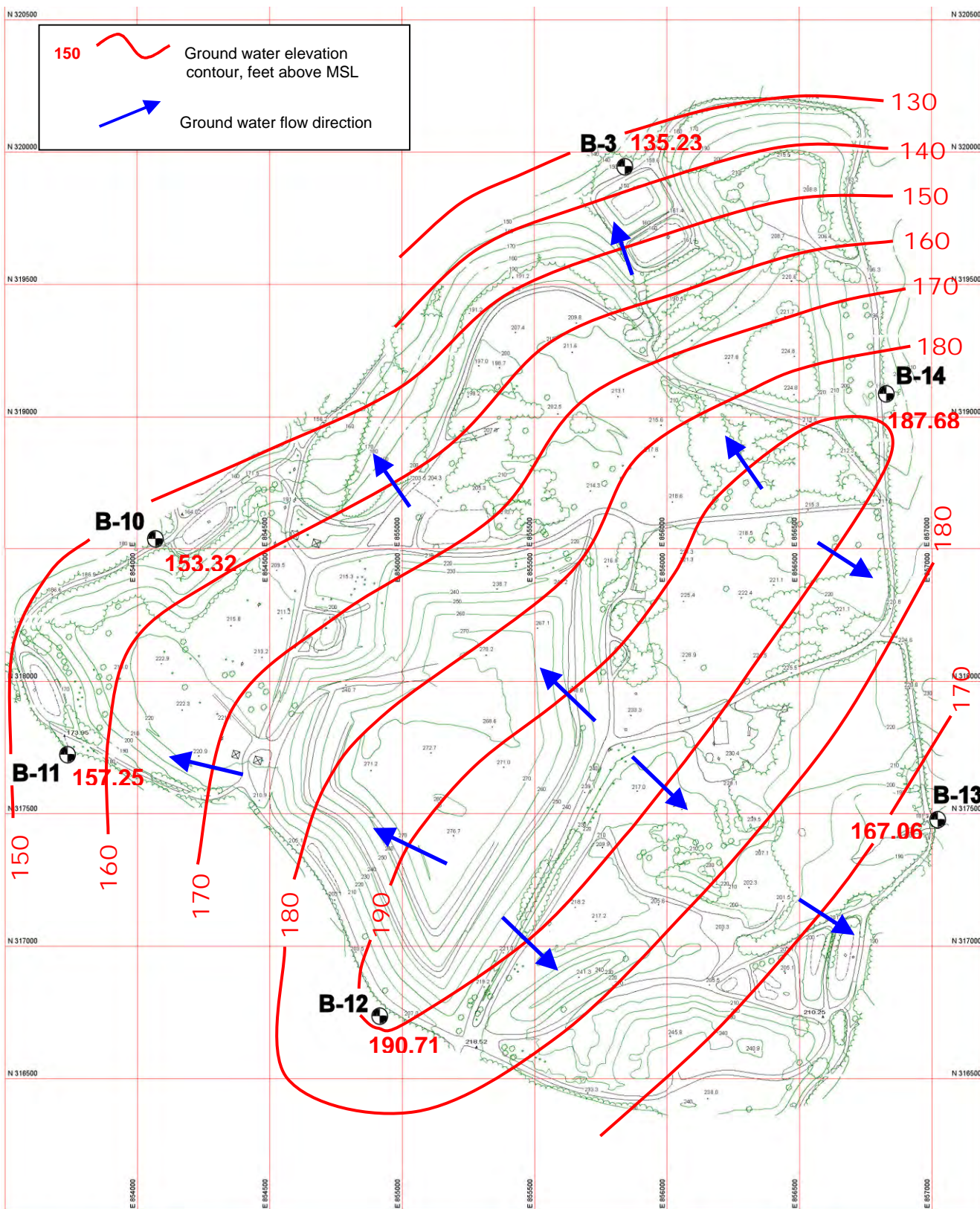
**Brandywine Ash Management Site Ground  
Water Contours for January 31, 1994**  
From: Porter, W.M. and Company, 2009.



**Brandywine Ash Management Site Ground  
Water Contours for July 23, 2002**  
From: Porter, W.M. and Company, 2009.



**Brandywine Ash Management Site Ground  
Water Contours for April 18, 2007**  
From: Porter, W.M. and Company, 2009.



**Brandywine Ash Management Site Ground  
Water Contours for July 16, 2009**

From: Porter, W.M. and Company, 2009.



## APPENDIX C

### Supplemental Alternative Source Demonstration

14 November 2018

Mr. Walter Johnson  
GenOn MD Ash Management LLC  
c/o Chalk Point Generating Station  
25100 Chalk Point Road  
Aquasco, Maryland 20608

Subject: Supplemental Alternative Source Demonstration  
Groundwater Detection Monitoring Program, Federal CCR Rule  
Brandywine Ash Management Facility – Phase II, Brandywine, Maryland

Dear Mr. Johnson:

Geosyntec Consultants, Inc. (Geosyntec) has completed statistical testing for potential statistically significant increases (SSI) over background concentrations in downgradient compliance monitoring wells at the Brandywine Ash Management Facility Phase II located in Brandywine, Maryland (the Site) pursuant to the Federal CCR Rule. **Table 1** (attached) shows multiple SSIs that were detected for Appendix III constituents in several downgradient compliance monitoring wells during the first three Detection Monitoring Program events (samples collected during October 2017, April/May 2018, and July/August 2018). Geosyntec previously completed an Alternate Source Demonstration (ASD) for Appendix III SSIs detected in the October 2017 samples. Therefore, many of the SSIs shown on **Table 1** for the April/May and July/August 2018 samples are simply recurrences of the same site conditions that were already considered by the previous ASD. That report concluded that the SSIs were due to migration of Appendix III constituents from the adjacent unlined Phase I CCR landfill area. Hence Phase I constituents are being detected in samples from the Phase II monitoring wells. SSIs for the April/May and July/August 2018 sampling events can be organized into three groups:

1. SSIs where the concentrations are less than or equal to the maximum concentration previously detected in those wells and that were evaluated by the previous ASD (most of the April/May and July/August 2018 results fall into this group);
2. SSIs where the concentrations have a Relative Percent Difference (RPD) within twenty (20) percent when compared to the maximum concentration previously detected in those wells and that were evaluated by the previous ASD (boron in B16 during April 2018 only; chloride in B37 during May 2018 only; sulfate in B16 during April 2018 only; TDS in B16 during April 2018 and July 2018, as well as B39 during May 2018 only; and pH in B39 during August only); and

3. SSIs where the concentrations have an RPD greater than twenty percent when compared to the maximum concentration previously detected in those wells that were evaluated by the previous ASD (boron in B15S during August 2018 only; fluoride in B15S during August 2018 only; and sulfate in B16 during July only).

**Group 1:** SSIs in Group 1 are clearly similar to the results evaluated by the prior ASD. Therefore, those SSIs are considered to be false positives because they have been previously shown to be due to migration of Appendix III constituents from the adjacent unlined Phase I landfill and are not discussed further herein.

**Group 2:** The SSIs in Group 2 are also similar to the results considered by the prior ASD and therefore are false positives because they have been previously shown to be due to migration of Appendix III constituents from the adjacent unlined Phase I landfill. This conclusion is based upon the acceptable measurement system error (i.e. measurement system error = sample collection error + laboratory analysis error) that is standard practice of the groundwater monitoring industry. For major solutes such as the Appendix III constituents (other than fluoride and pH), it should be possible to achieve an analytical RPD of 10 percent or less in the laboratory (Hem, 1992), but that does not include the additional RPD associated with sampling error. The U.S. Environmental Protection Agency (USEPA) guidelines for data validation of inorganics in groundwater samples indicates that an acceptable relative percent difference (RPD) of +/- 20 percent should be achieved for aqueous laboratory duplicate samples (i.e. separate analyses of two aliquots from one sample jar) as a metric of laboratory error. Per the USEPA data validation guidance<sup>1</sup>, RPD is calculated as:

$$RPD (\%) = \frac{(C1 - C2) \times 100}{[(C1 + C2)/2]}$$

where C1 and C2 are reported laboratory concentration results for a laboratory sample pair. Note that this USEPA 20 percent criterion does not include the variability from the sample collection component of the total measurement system. Therefore, the metric for sampling plus laboratory analysis variability of field duplicate samples (i.e. separate analyses of two aliquots from two separate jars from the same well) is greater than 20 percent. For purposes of this ASD, Geosyntec chose a conservative combined sampling and analytical RPD cutoff of +/- 20 percent. This value is more conservative than the +/-20 percent RPD value given in the USEPA data validation guidelines and is reasonable because the actual RPDs for field duplicates at the site are generally within 20 percent. Therefore, Group 2 SSIs are considered to be equal to previous concentrations within the standard acceptable measurement error in the groundwater monitoring industry. In

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<sup>1</sup> U.S. Environmental Protection Agency, 2017. National Functional Guidelines for Inorganic Superfund Methods Data Review, EQP-540-R-2017-001, January.

summary, these Group 2 SSIs are considered to be false positives due to sampling and/or analysis error.

**Group 3:** Geosyntec also evaluated the SSIs in Group 3. At well B15S two constituents (boron and fluoride) from the August 2018 samples have RPD values of 40 percent and 21 percent, respectively, compared with previous maximum detected concentration in the samples collected through October 2017 (that were considered by the previous ASD). However, both of these analytical results were qualified by the laboratory with a 'J' qualifier to indicate that the reported value is between the Method Detection Limit (MDL) and the Reporting Limit (RL). The J qualifier indicates that the laboratory measurement error is greater than that for constituents detected at a concentration greater than the RL (because it is approaching the limits of sensitivity of the analytical instruments). This approach is included in the USEPA data validation guidance. Hence these two Group 3 SSIs are subject to greater uncertainty (i.e. RPD greater than 20 percent) and the SSIs are considered to be false positives due to laboratory error.

Hem (1992)<sup>2</sup> indicates that the electrical charge balance of major cations and anions in a water sample with good laboratory analytical accuracy and precision under 'ideal conditions' should balance within approximately two (2) percent when the total dissolved solids (TDS) are greater than 250 milligrams per liter (mg/L). Such is the case for the groundwater samples from the compliance wells (except B15S and B26) at the Brandywine Phase II cell. A total major constituent analysis of cations and anions is not required by the Federal CCR Rule but it was completed for the July/August 2018 samples under another monitoring program. Therefore, the charge balance of cations and anions was calculated for the July 2018 sample from B16. As shown on **Table 2**, the total charge of anions (in milliequivalents per liter; meq/L) was 237 meq/L and the total charge of cations is 202 meq/L. There is an excess charge of anions totaling 15.8 percent (34.6 meq/L). In addition, the sum of the individual analyses of major cations and major anions (15,376 mg/L combined) exceeds the measured TDS value (13,400 mg/L) by 14.8 percent. The measured TDS value is more consistent with the field-measured specific conductivity (15,670 microSiemens/centimeter) than the summation of individual analyses<sup>3</sup>. Therefore, it is possible that the concentration of one or more anions in the sample reported by the laboratory was erroneously high. If the imbalance is due to biased-high sulfate concentration data, adjusting the reported sulfate concentration to achieve charge balance translates into subtracting 1,661 mg/L of sulfate from the laboratory-reported value. The laboratory reported concentration of sulfate was 8,380 mg/L for the July 2018 sample. Therefore, the adjusted sulfate concentration is 6,719 mg/L. The prior maximum detected sulfate concentration at B16 in the samples considered by the previous ASD was 6,410 mg/L. The RPD for these two values is 4.7 percent. Therefore, it is

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<sup>2</sup> Hem, J.D., 1992. Study and Interpretation of the Chemical Characteristics of Natural Water, Third Edition, U.S. Geological Survey Water-Supply Paper 2254.

<sup>3</sup> Hem (1992) indicates that for sulfate-rich waters TDS in mg/L is approximately equal to specific conductivity multiplied by 0.75.

likely that the sulfate SSIs for the July 2018 and April 2018 samples are false positives due to laboratory error.

In summary, this ASD shows that the SSIs detected for the April/May and July/August 2018 samples are false positives and are due to a combination of alternative sources as well as sampling and/or laboratory analysis error. Therefore, the site should remain in the Detection Monitoring Program.

If you have any questions regarding this letter or the approach it describes, please do not hesitate to contact the undersigned at 410.381.4333.

Very truly yours,



Mark Bauer  
Project Geologist



Robert M. Glazier  
Principal

Attachment

cc: Mark Nitz, GenOn  
Steve Frank, GenOn

**TABLE 1**  
**STATISTICALLY SIGNIFICANT INCREASE (SSI) TEST RESULTS**  
**Federal CCR Rule Appendix III Constituents**  
**Brandywine Ash Management Facility**  
**Supplemental Alternative Source Demonstration**

Analyte:		Boron	Calcium	Chloride	Fluoride	pH	Sulfate	TDS
Background:		25	6.32	14.1	<0.25	3.1 - 7.7	18.6	239
Well ID	Sample Date	µg/L	mg/L	mg/L	mg/L	S.U.	mg/L	mg/L
B15S	10/24/2017	13.6 J	1.93	3.9	0.25 U	5.0	13.3	39.5
B15S	5/2/2018	14.1 J	1.84	5.4	0.50 U	5.5	16.7	59.5 J
	5/2/2018 [1]	14.5 J	1.81	5.5	0.50 U	5.5	16.8	68.0
B15S	8/1/2018	36.4 J	1.60	4.8	0.31 J	5.7	15.0	60.5
B16	10/25/2017	49,500	377	1,580	0.25 U	6.8	6,410	11,000
B16	4/30/2018	58,200	426	1,870	0.50 U	6.7	7,250	13,400
B16	7/31/2018	53,500	385	1,850	0.50 U	6.9	8,380	13,400
B26	10/25/2017	17.0 J	4.08	8.8	0.25 U	4.3	13.2	53.0
B26	5/1/2018	22.3 J	4.45	10.0	0.50 U	5.2	12.1	67.5
B26	8/1/2018	18.6 J	4.85	9.9	0.50 U	5.2	13.4	59.0 J
B27	10/25/2017	632	42.7	56.0	0.25 U	5.9	153	519
B27	5/1/2018	665	53.9	23.4	0.50 U	7.0	74.1	419
B27	8/2/2018	547	41.4	13.4	0.50 U	7.1	53.7	306
B37	10/24/2017	2,050	104	157	1.0	4.3	624	1,120
B37	5/1/2018	1,430	90.2	179	0.61	5.0	422	964
B37	8/3/2018	899	56.1	125	0.39 J	5.2	197	512
B38	10/24/2017	14,900	360	203	0.45 J	6.3	2,530	3,580
B38	5/1/2018	14,000	421	248	0.50 J	6.4	2,390	3,260
B38	8/3/2018	14,400	341	225	0.50 J	6.8	2,360	3,270
B39	10/25/2017	4,870	69.4	426	0.51 J+	2.9 J	1,500	2,200
	10/25/2017 [1]	4,850	69.2	402	0.25 U	3.0 J	1,310	2,120
B39	5/1/2018	5,280	107	410	0.50 U	3.1 J	1,350	2,740
	5/1/2018 [1]	5,350	105	420	0.50 U	3.2 J	1,350	2,200
B39	8/3/2018	4,290	60.3	245	0.50 U	2.7 J	1,350	1,460

## Notes:

Concentration is a statistically significant increase (SSI) over background concentration. Fluoride follows the Double Quantification Rule.

µg/L micrograms per Liter

mg/L milligrams per Liter

S.U. Standard Units

J Constituent detected below reportable quantitation limit; result is an estimated value.

U Constituent not detected above method detection limit.

[1] Duplicate sample collected.

**TABLE 2  
B16 CHARGE BALANCE CALCULATION**

**Brandywine Ash Management Facility  
Supplemental Alternative Source Demonstration  
Brandywine, Maryland**

MAJOR CATION AND ANION INFORMATION								
Anion/Cations	Sodium	Potassium	Chloride	Calcium	Bicarbonate	Carbonate	Magnesium	Sulfate
Ionic Charge	1	1	-1	2	-1	-2	2	-2
Molecular Weight	22.98	39.098	35.453	40.08	61.02	60	24.305	96.06

INPUT (mg/L)	Well ID	Sodium (mg/L)	Potassium (mg/L)	Chloride (mg/L)	Calcium (mg/L)	Bicarbonate (mg/L)	Carbonate (mg/L)	Magnesium (mg/L)	Sulfate (mg/L)
		B16 (7/31/18)	3780	212	1850	385	612	0	157

OUTPUT (meq/L)	CONCENTRATION UNITS USED FOR CHARGE BALANCE EVALUATION								
	Well ID	Sodium (meq/L)	Potassium (meq/L)	Chloride (meq/L)	Calcium (meq/L)	Bicarbonate (meq/L)	Carbonate (meq/L)	Magnesium (meq/L)	Sulfate (meq/L)
	B16 (7/31/18)	164	5.4	-52.2	19.2	-10.0	0.0	12.9	-174

RESULTS	CHARGE BALANCE RESULT			
	Sum of Cations (meq/L)	Sum of Anions (meq/L)	Sum of Charge (meq/L)	% Charge Imbalance
	202	-237	-34.6	15.8%


$$\text{meq/L} = \left( \frac{\text{Concentration } (\frac{\text{mg}}{\text{L}})}{\text{Molecular Weight } (\text{mg/mmol})} \right) \times \text{Ionic Charge}$$

**Certification**


I, **William M. Steier**, a qualified professional engineer registered in the state of **Maryland**, verify the accuracy of the information in the *Supplemental Alternate Source Demonstration Report for the Brandywine Ash Management Facility Phase II Unit* based on my review and understanding of the requirements of 40 CFR 257.94(e)(2).

Printed Name: William M. Steier

PE License Number: 26728 State: Maryland

Signature: 

Date: 11/14/2018

Seal:  Stamp: